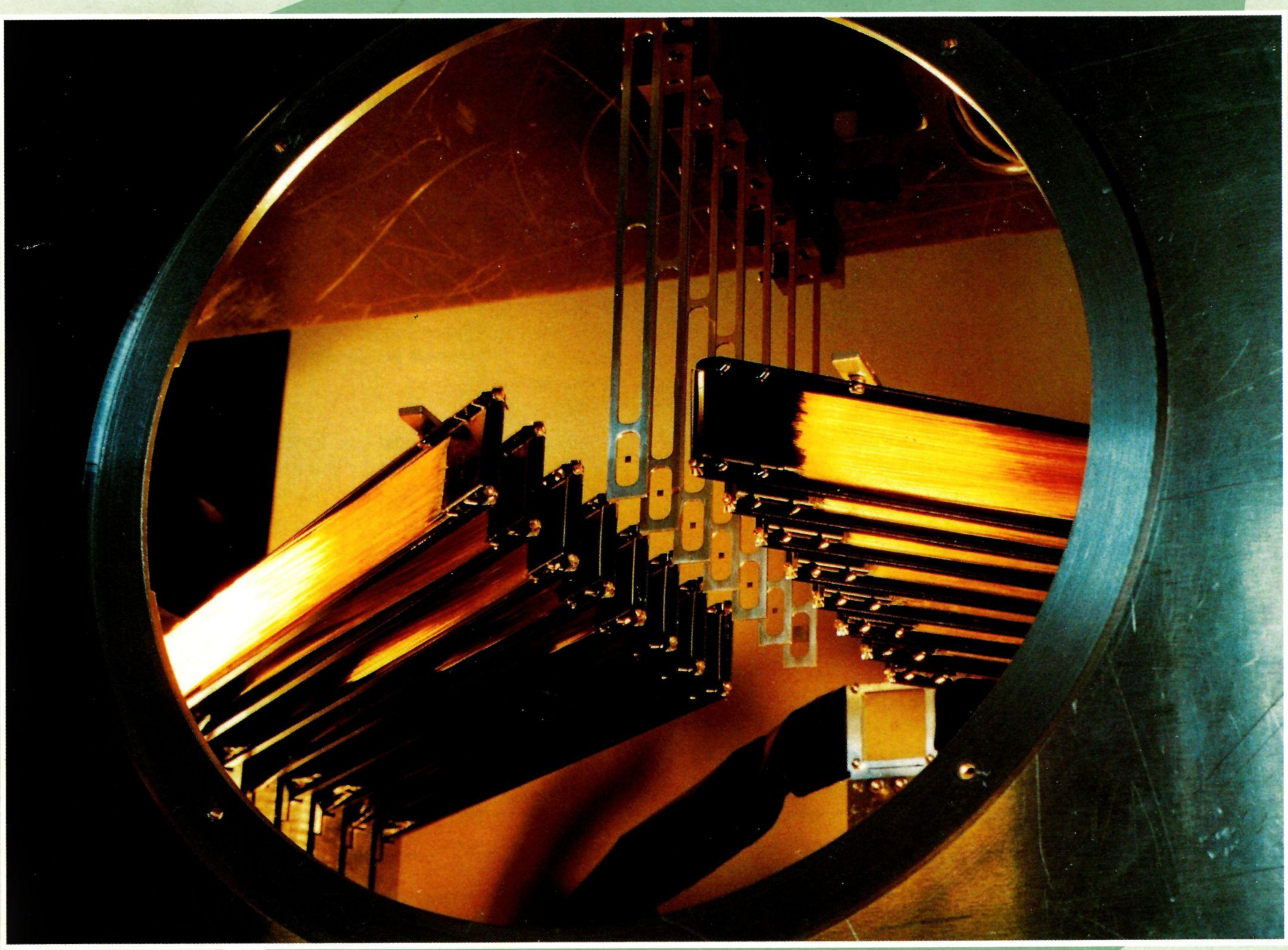
CERN COURIER

International journal of high energy physics

VOLUME 37 | 1 | JANUARY/FEBRUARY 1997



Advertising enquiries

Europe

Micheline Falciola
Advertising Manager
CERN
CH-1211 Geneva 23, Switzerland
Tel.: +41 (22) 767 4103
Fax: +41 (22) 782 1906

Rest of the world

Guy Griffiths
Advertising Manager, USA
International Publishers Distributor
820 Town Center Drive
LANGHORNE PA 19047
Tel.: (215) 750-2642
Fax: (215) 750-6343

Distributed to Member State governments, institutes and laboratories affiliated with CERN, and to their personnel.

General distribution

Jacques Dallemagne
CERN, 1211 Geneva 23, Switzerland

In certain countries, to request copies or to make address changes contact :

China

Dr. Qian Ke-Qin
Institute of High Energy Physics
P.O. Box 918, Beijing,
People's Republic of China

Germany

Gabriela Heessel or Monika Stuckenberg
DESY, Notkestr. 85, 22603 Hamburg 52

Italy

Mrs. Pieri or Mrs. Montanari
INFN, Casella Postale 56
00044 Frascati, Roma

United Kingdom

Su Lockley
Rutherford Appleton Laboratory,
Chilton, Didcot, Oxfordshire OX11 0QX

USA/Canada

Janice Voss
Creative Mailing Services
P.O. Box 1147
St. Charles, Illinois 60174
Tel.: 630-377-1589 / Fax: 630-377-1569

CERN COURIER is published monthly except January and August in English and French editions. The views expressed in the Journal are not necessarily those of the CERN management.

Printed by: Drukkerij Lannoo nv
8700 Tielt, Belgium

Published by:

European Laboratory for Particle Physics
CERN, 1211 Geneva 23, Switzerland
tel.: +41 (22) 767 61 11,
telex: 419 000 CERN CH,
telefax: +41 (22) 767 65 55

CERN COURIER only:
tel. +41 (22) 767 41 03,
telefax +41 (22) 782 19 06

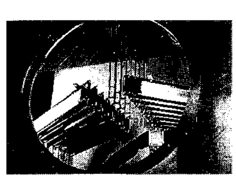
USA: Controlled Circulation
Periodicals postage paid at St. Charles, Illinois

ISSN 0304-288X

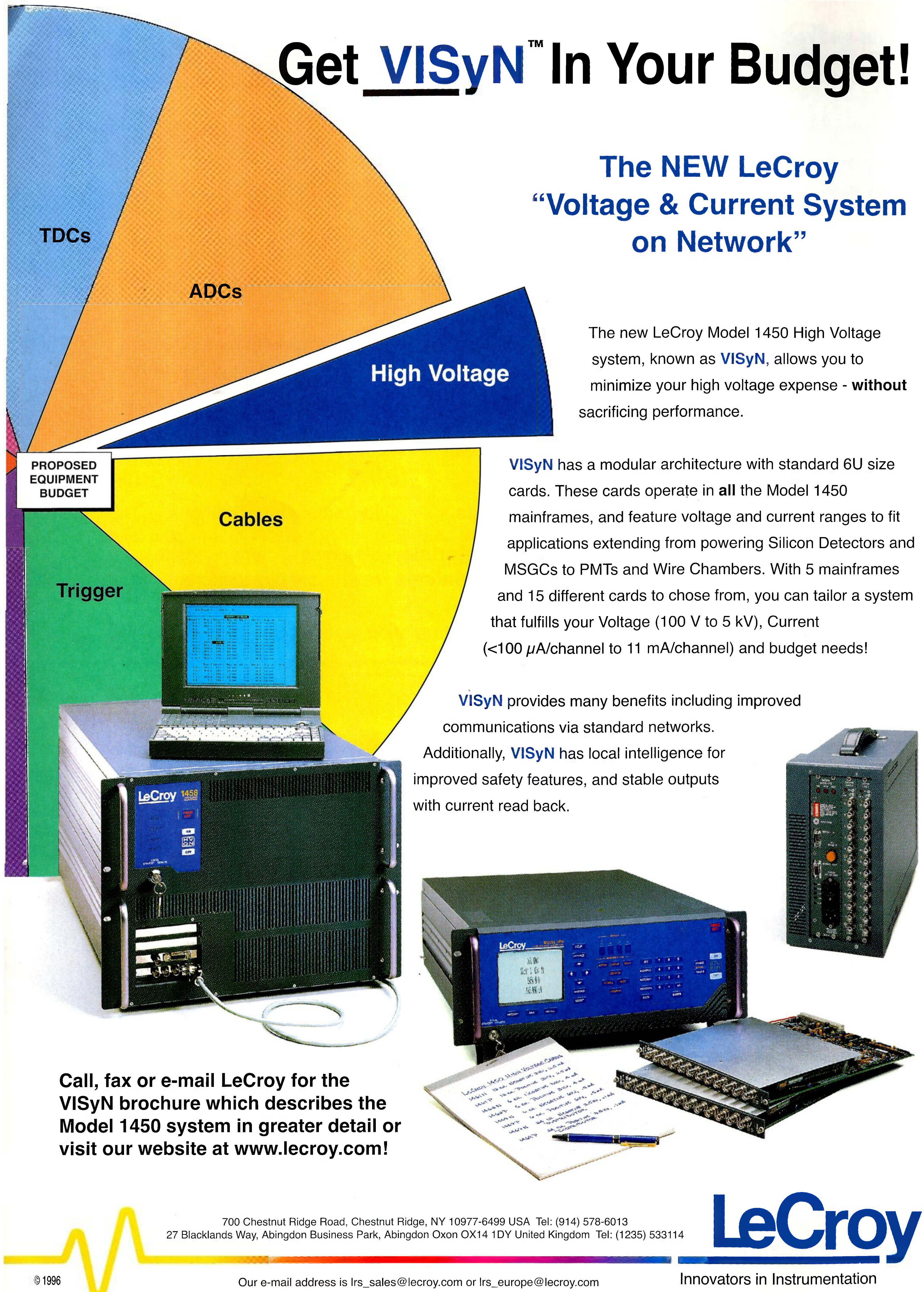
Volume 37
No. 1
January/
February 1997

Covering current developments in high energy physics and related fields worldwide

Editor: Gordon Fraser CERN.COURIER@ CERN.CH
Production and Advertisements:
Micheline Falciola
Micheline_Falciola@macmail.cern.ch
Advisory Board: E.J.N. Wilson (Chairman), E. Lillestol, M. Neubert, D. Treille; with L. Foà, E.M. Rimmer
World Wide Web http://www.cern.ch/CERN/Courier/



Cover photograph: Sub-target array of the NA50 heavy ion experiment at CERN, showing both sides of the retracted recognition system to identify which target element is 'hit'. Cherenkov light produced by particles in the quartz slabs is transmitted to photomultipliers by optical fibre bundles (Photo Guy Jacquet, IPN-Lyon).



Get VISyN™ In Your Budget!
The NEW LeCroy
"Voltage & Current System
on Network"
TDCs
ADCs
High Voltage
PROPOSED EQUIPMENT BUDGET
Cables
Trigger
The new LeCroy Model 1450 High Voltage system, known as VISyN, allows you to minimize your high voltage expense - without sacrificing performance.
VISyN has a modular architecture with standard 6U size cards. These cards operate in all the Model 1450 mainframes, and feature voltage and current ranges to fit applications extending from powering Silicon Detectors and MSGCs to PMTs and Wire Chambers. With 5 mainframes and 15 different cards to chose from, you can tailor a system that fulfills your Voltage (100 V to 5 kV), Current (<100 µA/channel to 11 mA/channel) and budget needs!
VISyN provides many benefits including improved communications via standard networks. Additionally, VISyN has local intelligence for improved safety features, and stable outputs with current read back.
LeCroy 1458
Call, fax or e-mail LeCroy for the VISyN brochure which describes the Model 1450 system in greater detail or visit our website at www.lecroy.com!
700 Chestnut Ridge Road, Chestnut Ridge, NY 10977-6499 USA Tel: (914) 578-6013
27 Blacklands Way, Abingdon Business Park, Abingdon Oxon OX14 1DY United Kingdom Tel: (1235) 533114
LeCroy
Innovators in Instrumentation
©1996
Our e-mail address is lrs_sales@lecroy.com or lrs_europe@lecroy.com

Economy class physics

At its December meeting, CERN's governing body, Council, took the important decision that the Laboratory's big project for the next millenium, the LHC proton collider, shall be completed in a single stage and planning shall proceed on the basis that the LHC will be commissioned in 2005.

When a green light for LHC had first been illuminated at the December 1994 Council meeting, the understanding was for a two-stage project, with an initial intermediate energy and the collider only attaining its design energy of some 7 TeV per beam in 2008. However at that time Council said that if sufficient interest and financial commitment were forthcoming from non-Member States, the project might be completed in a single stage.

Since then, non-Member State interest and commitment for the LHC have snowballed. Japan made an initial generous contribution of 5 billion yen, and at the December 1996 Council meeting pledged a further contribution of 3.85 billion yen (some 33 million dollars), subject however to final approval by the Japanese parliament. At the Council meeting, Japanese delegate Daisuke Machida said 'The Japanese government hopes that this decision substantially contributes to the success of future work at this famous research centre'.

Last year, agreements for the LHC accelerator had also been signed in March with India with a net value for CERN of $12.5 million, in June with Russia (50 million dollars), and with the Canadian TRIUMF Laboratory for an in-kind contribution with a value of $30 million Canadian.

In the US, a cooperation agreement has been drafted outlining a contribution to the LHC accelerator from the Department of Energy (DOE) of $200 million, and contributions from the DOE and the National Science Foundation for the ATLAS and CMS experiments at LHC totalling $330 million. CERN Council approved this text.

However this impressive LHC blueprint for physics in the next millennium was approved against a sad background of budget reductions. Early last year, CERN management had been congratulating itself on having obtained initial LHC approval and gaining significant assurances of backing from non-Member States. Then in an August bombshell, Germany unexpectedly sought a reduction in its contribution to the CERN budget.

This proposal naturally received a hostile reception at CERN but also did not find favour with most other Member States. However after intense discussion, it was decided that while LHC funding would remain intact, CERN's overall budget, compared to that foreseen in 1994, would be reduced by an unprecedented 7.5% in 1997, with reductions increasing to 8.5% in 1998-2000, and to 9.3% thereafter. Take-home pay of CERN staff will be cut by 2.5%.

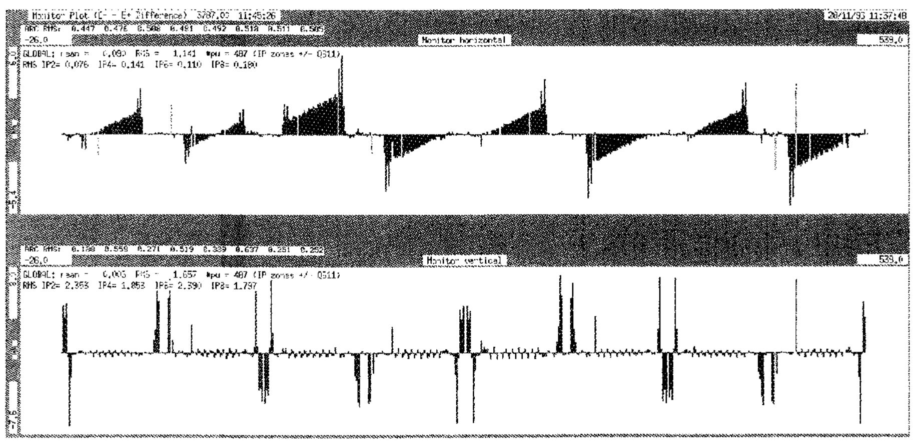
However Council gave CERN management additional flexibility to bankroll the LHC, with payments extended to 2008 if need be.

With manpower and expenditure for LHC untouched, these cuts fall on the remainder of the research programme. In his traditional end-year summary of scientific achievements, CERN Director General Chris Llewellyn Smith proudly pointed to an impressive array of results. The tone for 1996 had been set with the announcement of the discovery of antihydrogen at the LEAR low energy antiproton ring. Another LEAR result had been the confirmation by the Crystal Barrel experiment of a 'glueball', a subnuclear state made of gluons, the particles which carry the inter-quark force, but no quarks. The heavy ion experiments at the SPS synchrotron had uncovered important additional evidence that the long-awaited quark-gluon plasma, the high temperature precursor of everyday nuclear matter, was within reach, while the LEP electron-positron collider provided its first batch of pairs of W particles, the electrically charged carriers of the weak nuclear force.

Applauding this latest research harvest, Llewellyn Smith hinted that future such summaries would risk being less impressive. The LEAR low energy antiproton ring is now closed and the experimental programme at the SPS is gradually being run down, sacrificial lambs to the LHC.

Around the Laboratories

Over 500 beam position monitors around the 27-kilometre LEP ring trace carefully the circulating particles. This shows the difference between the electron and positron closed orbits. The horizontal plane (above) shows characteristic 'sawteeth' - the energy difference between the two beams - reaching a maximum when one beam receives a radiofrequency kick while the other is just arriving after experiencing the inexorable slow energy loss due to synchrotron radiation. The vertical plane (below) shows how the circulating bunch trains are bumped by electrostatic separators to avoid unwanted collisions between electron and positron bunches.



CERN
One year of LEP2

LEP2, as CERN's LEP electron-positron collider is now called to underline its higher beam energies, finished 1996 operations in mid-November and the four big experiments retired to continue carefully analysing the new physics conditions enjoyed during the first complete year of LEP2 operations. LEP2's 1996 debut was a major success, demonstrating the impressive accomplishments of its superconducting acceleration power.

After six years faithfully logging LEP electron-positron annihilations into Zs, the neutral carriers of the weak force, around 91 GeV, 'LEP 1.5', flexing its first superconducting radiofrequency muscles, debuted in 1995 at a higher energy of 140 GeV (70 GeV per beam).

With additional superconducting power on board, last summer the fully-fledged LEP2 ran for six weeks at 161 GeV (80.5 GeV per beam), giving the four experiments, Aleph, Delphi, L3 and Opal, their first taste of W pairs, the electrically charged carriers of the weak force (October 1996, page 18).

This initial W pair collection run halted as scheduled in mid-August for LEP2 to reinforce its superconducting radiofrequency power by the addition of 28 more cavities, and on 19 October the machine duly responded with a new high energy of 172 GeV (86 GeV per beam). The integrated luminosity (a measure how many electron-positron collisions were delivered for physics) for the year reached 24 inverse picobarns, a modest total by LEP standards, but nevertheless an encouraging score as the machine had to remain silent for long periods while its additional superconducting power was being installed.

LEP2's 176 superconducting radiofrequency cavities and couplers worked well, but delicate forced oscillation effects effectively limited the electron-positron beam currents which could be handled.

In the continual search for improved operational conditions, LEP has tried out a series of beam tunes. 1996 operation began with a mixed 108°/60° horizontal/vertical phase advance using a beam configuration of four trains of two bunches per beam. However this did not live up to expectations and operation shifted to a 90°/60° tune. This was a spectacular success, with luminosity increasing faster than it ever had before, and a maximum instantaneous luminosity of 3.4 x 10^{31} per sq cm per s. After valiant radiofrequency efforts to improve the reliability of an extremely complex system, LEP2's act began to look very together, and the operations crew were once more able to enjoy the satisfaction of choosing the moment to dump coasting beams and replace them with fresh particles, rather than being the hapless victims of teething problems and equipment failures.

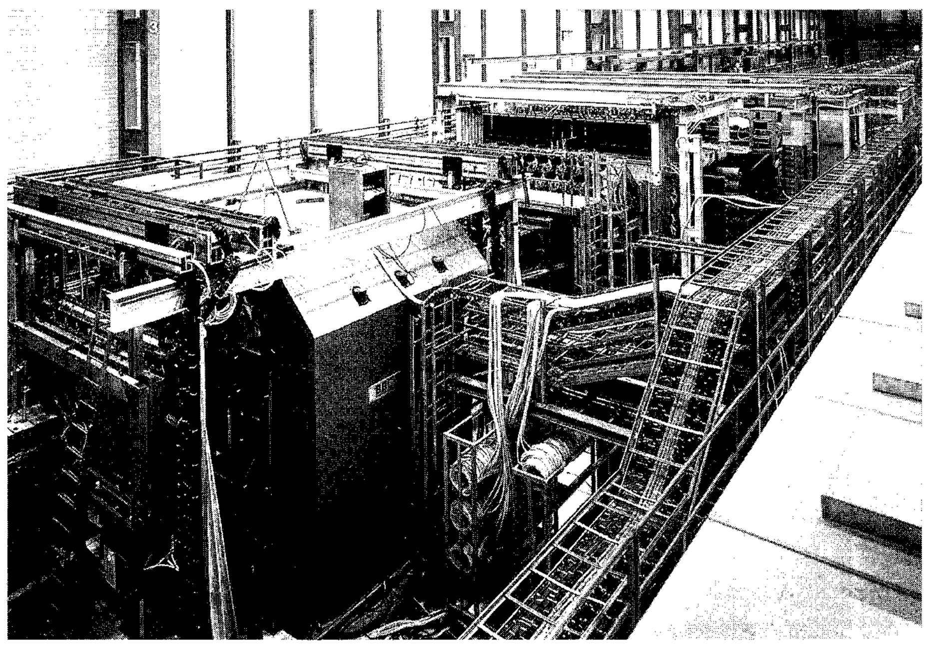
The cautionary radiofrequency limit meant that four bunches per beam were used for the most part. However when this limit was raised, operation switched to bunch trains, with four trains of two bunches per beam.

However higher LEP2 energies were expected to increase the beam size and a compensatory new 108°/90° low emittance tune was scheduled. At the beginning of November, LEP was shut down again briefly for its sextupole magnets to be recabled to handle these new conditions. While the goal was to optimize the beam size (emittance), the operations crew were disappointed when the new scheme appeared to have possible implications for beam stability. The dynamic aperture, the range of running conditions under which beams are stable, was much more restricted than had been expected.

In January, LEP team traditionally migrate to a workshop in Chamonix in the French Alps to review the past year's achievements and thrash out plans for the coming year.

On the machine front, with no more empty space for extra superconducting cavities to be installed, a major phase of

The EMC spectrometer in 1978 during CERN's first muon physics run. At the back of the hall (top right) can be seen CERN's other big muon experiment, BCDMS. (Photo CERN X 500-5-78)



superconducting cavity installation is complete. To take the beam energy higher, this winter 34 of LEP's 120 conventional radiofrequency accelerating cavities will be removed and replaced by 32 superconducting ones, opening up the prospect of 94 GeV per beam for 1997.

Over the muon

In 1974, 45 physicists from 13 institutions put their names to CERN proposal SPSC/P18, and a new era in particle physics history was born. The European Muon Collaboration, EMC, grew to over 70 collaborators, and collected its first data in 1978 with the new Super Proton Synchrotron high intensity muon beam. Last September, the Spin Muon Collaboration, SMC, final successor to the EMC, had its final run, bringing to an end a 22 year era of muon physics with the EMC spectrometer.

By today's standards, 70 collaborators seems modest, but the EMC proposal came at a turning point in particle physics research. For the first time, collaborations building electronic counter experiments were attaining cast lists only previously seen in bubble chamber collaborations.

The original EMC, with Erwin Gabathuler as elder statesman, stayed together until 1986, publishing 71 papers and twice confounding the world of physics with unforeseen results. The paper announcing one of these was still in the top-20 chart of most cited high energy physics papers seven years after publication (March 1995, page 21).

Its initial task complete, in 1986, the EMC fragmented as members migrated to experiments preparing for physics at the Large Electron Positron collider, LEP. A new collaboration took over and upgraded the apparatus, ready to look deeper into questions raised by the unexpected EMC results. The new collaboration christened itself the New Muon Collaboration, NMC, and ran until 1991 before passing the baton to the Spin Muon Collaboration.

CERN's muon programme was established with the goal of measuring the momentum distribution of quarks inside nucleons, the so-called nucleon structure functions. This initial task was to provide essential input for understanding the results of proton-proton collisions at the ISR, as well as the proton-antiproton collisions foreseen at CERN's Super Proton Synchrotron collider. Structure function results have lost none of their importance in the intervening years, and will be equally as vital at the Large Hadron Collider, LHC, as they were at previous generations of hadron collider experiments.

In the early days of CERN's muon programme, two experiments shared the same beam and the same hall. The EMC was first in line and downstream was another major experiment, initially led by Carlo Rubbia and named BCDMS after the initials of its collaborating institutions. This arrangement may appear to be uneven, with EMC getting beam priority. But CERN's muon beam delivered around 10 million muons in each two second pulse, and for each pulse, just 100 muons collided in the EMC target, leaving plenty for BCDMS.

In the simplest picture of nucleons, a proton or a neutron contains three quarks. But reality is a little more complex, the gluons sticking these three so-called valence quarks together sometimes split momentarily into pairs of quarks and antiquarks. This leads to a foaming 'sea' of low-momentum quark-antiquark pairs as well as the three high-momentum valence quarks.

EMC and BCDMS measured the distribution of momenta of all these quarks by firing high energy muons deep inside nucleons, and measuring the way they bounced off the quarks inside. Both experiments started off using targets of heavy nuclei, maximizing the probability that an incident muon would strike a proton or neutron. They later used targets of deuterium, where the nucleons are much less densely packed.

Physicists expected little difference between the structure functions from light nuclei and those from heavy ones, but when EMC physicists compared their iron and deuterium data, they found a rather different picture. The quarks inside nucleons embedded in a heavy iron nucleus behave very differently from those inside the almost free nucleons in a deuterium nucleus. This effect came to be called the EMC effect, and was the first surprise to come out of CERN's muon programme.

The second came in a later experiment by the EMC in which polarized muons were fired at polarized protons. Just like miniature spinning tops, protons spin about their axes, and by scattering polarized muons from polarized protons, information can be gleaned about the spin of the quarks inside. It was once thought that the proton's spin comes simply from adding up the spins of the quarks, but the EMC measurement showed that the quark spins largely cancel out, leaving the proton's spin in crisis.

The EMC's successors have studied these effects in depth. NMC concentrated largely on the EMC effect, which is now extremely well measured. Theoreticians have been scratching their heads to try and explain it, and many models have been proposed. Some have fallen by the wayside, but the jury is still out on what the real cause of the EMC effect might be.

The SMC, as its name suggests, concentrated on the spin crisis, and devised a state-of-the-art polarized target specifically for the job. SMC results reveal that only one fifth of the proton's spin comes from quarks. The rest, it is now believed, must be due at least in part to spinning gluons.

For now, muon physics takes a break at CERN. But with the proton's spin still a mystery, experiments are at the planning stage to carry on where SMC has just left off.

In the right channel

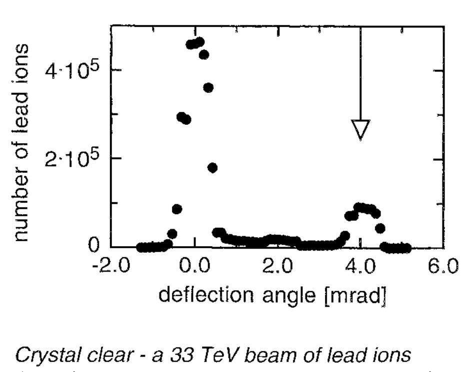
Thanks to 'channeling' - the steering and deflection of particles by the strong fields due to the atomic symmetry in crystals - a tiny crystal weighing a few grams, when mechanically bent by just a few microns, can have the same effect on charged particles as a bending magnet weighing several tons.

This effect has been investigated for many years. At Serpukhov, near Moscow, proton beams have actually been extracted and delivered to various experiments in this way, while at CERN, a bent crystal is used in a novel orientation to derive the twin beams for the NA48 experiment measuring CP violation. Bent crystals are also being studied at Dubna and Fermilab.

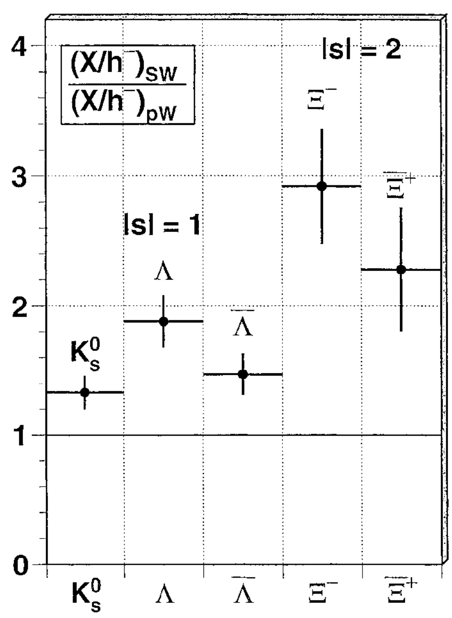
Work so far has concentrated on the relatively easily manufactured silicon crystals, but in 1996 an experiment at CERN used germanium. Its heavier nuclei with a bigger charge have a greater effect on steering the beam particles, giving an effective bending efficiency as much as a hundred times larger than silicon at high energy and large deflection angles.

CERN does not yet use bent crystals to extract the beams for actual experiments, but a series of 'machine development' trials have extensively explored the feasibility of this approach. In 1996, proton beams of 14, 120 and 270 GeV were extracted. In another recent development at CERN, a high energy beam of lead ions, fully stripped of electrons (82-fold charged ions of 270 GeV per charge, giving a total energy of 22 TeV) was successfully extracted from the SPS by a bent crystal, the first time that such high energy ions have ever been handled in this way.

Other tests, performed by an Aarhus-CERN collaboration in an external SPS beamline, showed that 33 TeV lead ions (400 GeV per charge) are deflected by crystals to the same extent as protons of an equivalent momentum. These crystals, typically 50 millimetres in the beam direction, 10 mm wide and 1 mm thick, can bend high energy beams through 20 milliradians and more, enough to deflect the beam by 20 metres over a kilometre.



Crystal clear - a 33 TeV beam of lead ions (400 GeV per charge) at CERN was steered through four milliradians using a bent crystal. About 15% of the beam particles were channeled and deflected.



Comparing nucleus-nucleus collisions to those of protons on nuclei, the three WA experiments based on the Omega spectrometer find that particle production does increase with strangeness content - there are more lambdas (one unit of strangeness) than pions (no strangeness), and more ksis (two units of strangeness) than lambdas.

Goliath and the North-West passage

In the reorganization of fixed target physics at CERN's SPS synchrotron in the runup to CERN's LHC proton collider (November 1995, page 5), the heavy ion programme is being focused on the North experimental area.

Research with heavy ions began at the SPS ten years ago, and has been traditionally split between the West and the North experimental areas. In the West area, a valuable series of experiments has been carried out using the general-purpose Omega spectrometer - WA85 using sulphur beams on a tungsten target, WA94 using sulphur beams on a sulphur target, and WA97 using lead beams and a lead target.

The West area has also been the home of several other heavy ion studies, including the large WA93/98 spectrometer, with the Plastic Ball detector, originally used at the Berkeley Bevalac, housed inside the Goliath magnet together with a downstream lead-glass calorimeter.

A particular objective of the series of experiments at the Omega spectrometer has been to measure the yields of particles carrying the strangeness quantum number - kaons and hyperons. An increased strangeness yield is expected to be one signal for the onset of the long-awaited quark-gluon plasma - a 'soup' formed when the nuclear matter formed in the collision gets so hot and so compressed that the boundaries between individual subnuclear particles melt.

Comparing nucleus-nucleus collisions to those of protons on nuclei, the three WA experiments based on the Omega spectrometer find that particle production does increase with strangeness content - there are more lambdas (one unit of strangeness) than pions (no strangeness), and more ksis (two units of strangeness) than lambdas. More recently, WA97 has seen signs of increased omega production (three units of strangeness) compared with ksis. This strangeness concentration suggests that quark-gluon plasma is not that far away.

To continue this investigation, NA57, a new experiment by a collaboration of scientists from the Czech Republic, France, Italy, the Netherlands, Norway, Russia, Slovakia and the UK, as well as CERN, will build a new spectrometer in the SPS North Area.

The new experiment will also use a lower ion beam energy, 40 GeV per nucleon, as well as the previous 160 GeV, extending the coverage of possible quark-gluon transition.

The planned setup resembles WA97, with a spectrometer consisting of series of silicon pixel arrays inside the Goliath magnet. This magnet, originally built at Saclay, was used in a photoproduction experiment in the North Area and subsequently shifted to the West Area for work with WA93/98. With its career path in the West area now at an end, Goliath is to make the trek back to the North.

NIKHEF More AmPS

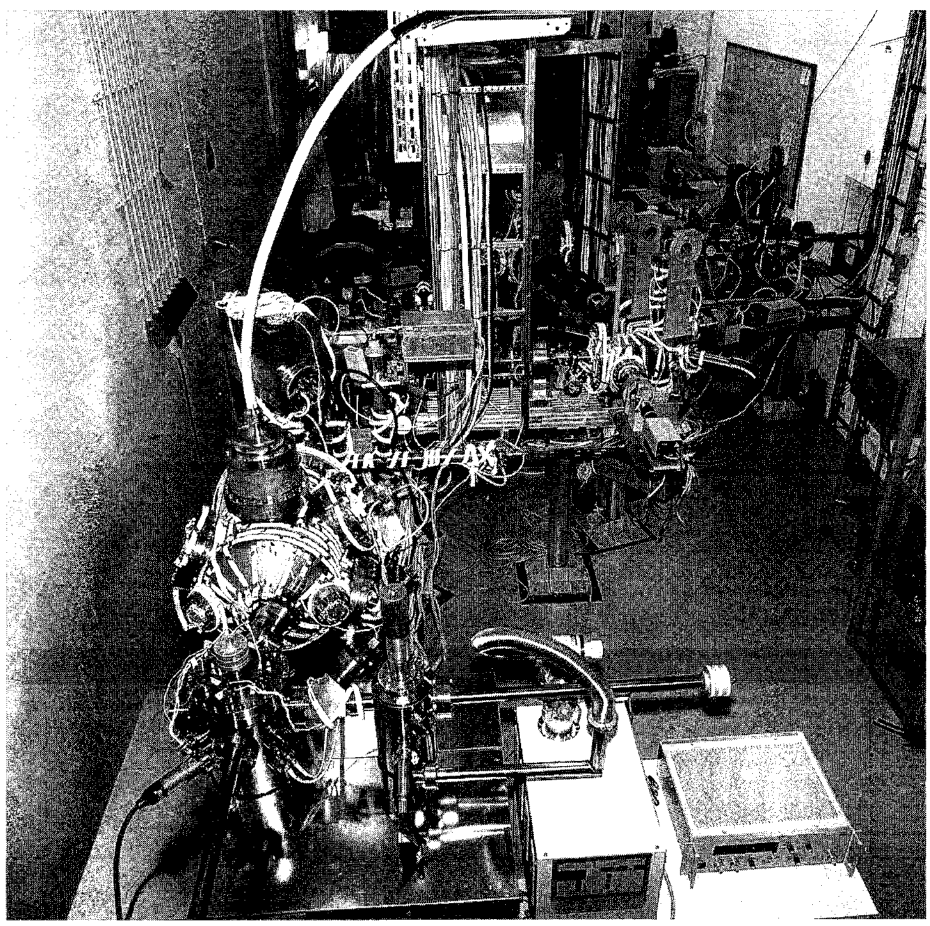
During a preliminary run last September, longitudinally polarized electrons were stored in the Amsterdam Pulse Stretcher (AmPS), the 210-metre electron storage ring at the Dutch NIKHEF research centre.

Produced from a strained crystal of gallium arsenide using a circularly polarized laser beam, the polarized electrons were then grouped into bunches. After acceleration to 400 keV, the electron spin orientation was manipulated by an arrangement of electric and magnetic fields. Finally, the electrons were accelerated to 600 MeV and injected into AmPS.

At present, the system is optimized for the first series of experiments this year. Amsterdam is the first place in the world where longitudinally polarized electrons are actually injected and stored for long periods of time. (Longitudinally polarized electrons produced the same way at the SLAC linear accelerator, Stanford, are only briefly stored in a damping ring en route to their once-only passage down the linac.)

In most larger storage rings, beams of transversely polarized electrons are created via the Sokolov-Ternov effect (when electrons flip their spin

Injector for the 210-metre Amsterdam Pulse Stretcher (AmPS) electron storage ring at the Dutch NIKHEF research centre which now stores longitudinally polarized electrons. On the left is the gun chamber which produces 100 keV polarized electrons. The extracted electrons are bent through 90° and pass through a Z-shaped spin manipulator. Top right is a Mott polarimeter. The source was built at the Budker Institute, Novosibirsk, which has been closely cooperating with NIKHEF since 1986.



after emitting synchrotron radiation). This happens more often for electrons with spins parallel to the magnetic field in the ring than for those with anti-parallel spin, resulting in an excess of the latter. In these cases, longitudinal polarization has to be established using special spin rotator magnets, as is done at the HERA electron ring at DESY, Hamburg.

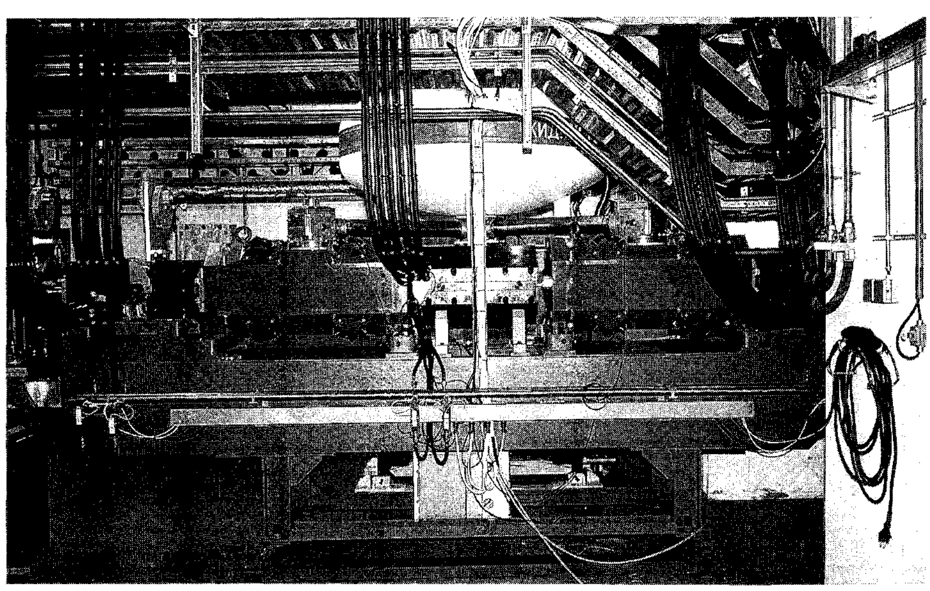
But producing polarization by synchrotron radiation depends on beam energy and on the strength of the field, and in the AmPS configuration would take up to a week. Preference was therefore given to direct production of longitudinally polarized electrons in a gallium arsenide source.

The source was built at the Budker Institute, Novosibirsk, which has been closely cooperating with NIKHEF since 1986. In maintaining the required ultra-high vacuum (10-9 Pa), NIKHEF also profits from previous experience at SLAC.

Inside the storage ring, the longitudinal electron polarization is conserved by a 'Siberian Snake'. This superconducting solenoid, also built in Novosibirsk, ensures that the electrons arrive properly polarized at the target. The overall polarization is measured using Compton-backscattering and found to be the same as at the source.

For the first experiments, using a polarized internal helium-3 target, NIKHEF aims for a current of more than 100 mA.

The polarized beam is accelerated in 0.7 microsecond pulses and each



Inside the AmPS storage ring, longitudinal electron polarization is conserved by this 'Siberian Snake' superconducting solenoid, also built at Novosibirsk.

pulse fills the entire storage ring. A continuous beam of 100 mA is then obtained by "stacking" the individual pulses on top of each other.

It is a challenge to reach a high stacking efficiency, demanding that the beam shifts as little as possible. Such shifts easily occur when a new bunch is injected and may lead to losses. This is made more difficult since there is little room: the beam must pass through the internal target, a tube 40 cm long and only 15 mm wide.

This target, built at NIKHEF, is of similar design to that used in the HERMES experiment at DESY. Rarefied gas is pumped through a T-shaped storage cell which is placed inside the beampipe. Atoms spend on average 5 ms in this open-ended cell. They are polarized beforehand by circularly polarized laser beams in combination with a weak external magnetic field. The target thickness inside the storage cell is about 2 $\times 10^{15}$ atoms per sq cm and the polarization is about 50%. There is no background from scattering in the target walls. For the same reason low energy recoil particles can be detected and this allows different final states to be discerned.

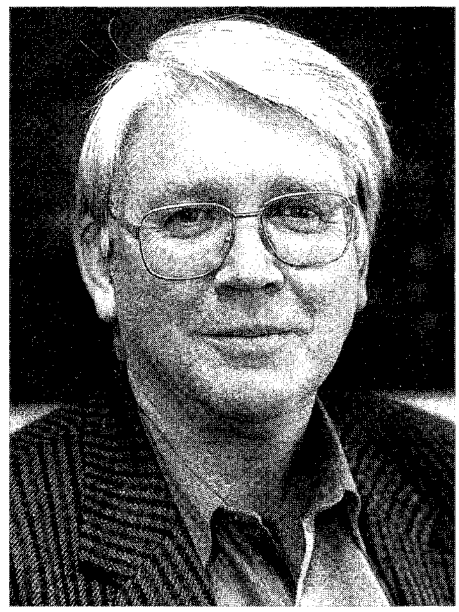
Scattered electrons are detected in the 20-ton Big Bite detector built at the Budker Institute. The experiments aim to compare the magnetic moment of helium-3 with that of the neutron. The helium-3 nucleus can, to a good approximation, be described as two protons with anti-parallel spin and one neutron. The spin of the nucleus is then to a large extent equal to the neutron spin. Precision experiments at NIKHEF will allow the small deviations to be studied.

The polarization also gives a handle on the neutron charge distribution. There is a worldwide effort to measure this charge form factor - experiments are being prepared at Mainz, CEBAF/Jefferson and MIT. However these use external targets with extracted polarized electron beams.

ICFA Collaboration

With international collaboration now such an essential part of high energy physics, ICFA - the International Committee for Future Accelerators - provides a useful forum to discuss plans and exchange opinions. A key feature of the ICFA calendar is its triennial 'perspectives' seminar, and the fifth such meeting, held at the Japanese KEK Laboratory from 15-18 October, reflected current objectives and concerns.

The main official statement said 'The meeting focused on the high energy frontier. The LHC proton collider project at CERN is essential for progress in the field and ICFA hopes that it will be completed as early as possible. It will address today's key questions and open a new energy domain. Its importance is indicated by the commitment of CERN non-Member States to support both the facility and the experiments. The LHC is becoming a true world facility. We note with concern recent indications of possible problems in CERN Member States with LHC funding. Stable funding is important for effective realization of such large projects. ICFA is therefore pleased to note that the Member States recently "reaffirmed their strong and unanimous support for the LHC programme and their wish to find a quick and stable solution to the



DESY Director Bjorn Wiik is the new chairman of ICFA - the International Committee for Future Accelerators.
(Photo Patrick Piel)

budget problem which will allow the LHC to be completed in a single stage as early as possible". (See page 1.)

Much of the progress of the past 25 years has come because of the different capabilities of two types of accelerator: hadron and electron colliders. Thus the second major focus of the seminar was on progress in developing the technology that will allow the construction of an electron linear collider that will complement the LHC. A well-coordinated research and development programme has been underway for many years. It now appears that an engineering design study can begin in the next few years that will result in a proposal for a specific project. We believe that such a facility should be realized as a world-wide enterprise on a basis developed jointly by interested scientific communities and their governments.

The seminar included reviews of the ongoing programmes close to completion at the world's particle accelerator laboratories. Difficult financial climates in most regions of the world have required hard choices. Even so, ICFA notes impressive progress and anticipates that the coming few years will result in substantial advances in our understanding of the nature of matter and forces.'

As described in reports at the meeting, research and development work on electron linear colliders is pushing ahead confidently on a broad front, with different accelerating radiofrequency bands and techniques being studied at major laboratories in Europe, the US, Japan and Russia (see page 34).

Also presented at the meeting were plans for the LHC machine and its experimental programme (which could have bright prospects for developing supersymmetry - see page 21), perspectives for possible electron-positron physics, and advanced accelerator technologies.

Collaboration means communication, and another area where high energy physics has been particularly influential is the field of telecommunications, where the need for large collaborations with wide geographical spreads to share large volumes of data has spawned major projects for high bandwidth transmission, and in particular catalysed the development of the World Wide Web on the internet.

Thus a second ICFA statement said 'Over the past two decades, high energy physics experiments have become fewer in number and larger. They are now often carried out at laboratories far from home institutions. Indeed, experiments are frequently on other continents.

The ability of researchers to participate fully in the life of their home institutions and simultaneously to fulfil their commitments to the preparation, data-taking and analysis of their experiments has come to depend crucially on access to good computer networking.

The availability of powerful low-cost distributed computing, the existence of wide-area networks with the potential for high-bandwidth transmission, the availability of powerful networking software such as the World Wide Web, and the increasing maturity of video-conferencing technology, have all changed the ways in which widespread collaborations operate. The simultaneous use of WWW and video-conferencing forms an effective way for remote groups to participate meaningfully in decision-making processes, and to collaborate significantly on data analysis and the preparation of publications. However for this to be really effective, adequate bandwidth must be available on all of the frequently used paths, whether between the host laboratory and the remote institutions, or between the various remote institutions.

ICFA notes with satisfaction that the major collaborations and host laboratories involved have actively deployed these new modes of communications and encouraged their use. ICFA urges that all countries and institutions wishing to participate even more effectively and fully in international high energy physics collaborations should: review their operating methods to ensure they are fully adapted to remote participation; and strive to provide the necessary communications facilities and adequate international bandwidth.'

On 1 January 1997, Fermilab Director John Peoples officially handed over the chairmanship of ICFA to DESY Director Bjorn Wiik.

Schooltime

CERN's calendar includes three regular schools - for accelerators, computing and physics.

The 1996-7 academic year for accelerator schools started with a course jointly organized by the CERN Accelerator School and its opposite numbers, KEKPAS in Japan and USPAS in the United States. Over a hundred participants, mostly but not exclusively from Asia, assembled in early September to learn about "RF Engineering for Accelerators" at Shonan Village Centre, Japan.

The team of lecturers consisted of experts from Asia, Europe and North America, as well as from Russia, which will become the fourth partner in this World Accelerator School when the next course in the series is held in Oxford, England, in 1998.

One of the highlights of the school was a practical course on microwave measurements set up by John Byrd and Fritz Caspers with the generous support of Hewlett Packard who provided a number of network analysers and other microwave equipment.

Soon after, in late October, CAS held their "Introduction to Accelerator Physics" course in Cascais, Portugal, in conjunction with the Laboratório de Instrumentação e Física Experimental de Partículas, Lisboa. This, the first of three courses designed to span the field up to the most advanced concepts, attracted almost 100 participants – an encouraging sign that a new generation is eager to contribute to accelerator technology.

A number of the participants at these two schools had scholarships funded by UNESCO for scientists and engineers from developing countries, including representatives from China, India, Mexico, and Nigeria. UNESCO will continue to award these scholarships for future schools.

The academic year continues in 1997 with a school on Magnet Measurements (Measurement and Alignment of Accelerator and Detector Magnets) in Anacapri, Italy, organized in collaboration with INFN Naples and local university departments, from 11-17 April, and an Intermediate Level course on Accelerator Physics in Gjøvik, Norway, organized in collaboration with the University of Oslo, from 1-12 September.

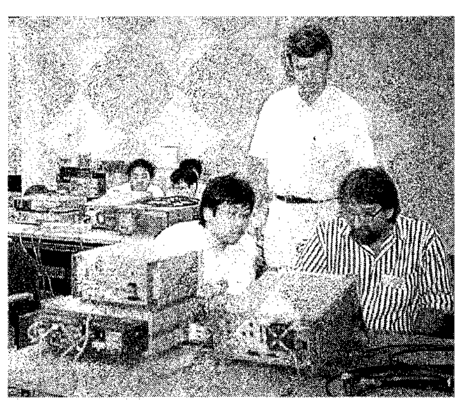
Further information from the CAS Secretariat, Mrs. S. von Wartburg, AC Division, CERN, CH-1211 Geneva 23, fax +41 22 767 5460, e-mail Suzanne.von.Wartburg@cern.ch

Meanwhile the 1996 CERN School of Computing, from 8 - 21 September, at the Hotel Zuiderduin, Egmond aan Zee (Netherlands), was organized in collaboration with NIKHEF and the Dutch ASCI (Advanced School for Computing and Imaging) and was the first CERN School to be so combined. The total number of participants was 91; 30 ASCI students, who participated in the first week only, and 61 non-ASCI.

The impressive computing infrastructure included one SUN file server, 22 SUN workstations and 6 X-terminals workstations used for the laboratory work, and 4 PCs for e-mail. The themes treated were: Imaging, Parallel and Distributed Computing, Networks and Electronic Highway, Data Acquisition Systems, Collaborative Engineering and Simulation, Detectors/Imaging and Modern Programming Language Trends, in 47 one-hour lectures and 12 hours of tutorials and laboratory work, by 23 speakers.

The twentieth CERN School of Computing, at Pruhonice (Prague), Czech Republic, from 17 - 30 August is organized in collaboration with the Czech Academy of Sciences and the Charles University, Prague, and is also sponsored by the Computational Physics Group of the European Physical Society. Covering Information Systems, Real-Time Instrumentation, Software Production and Visualisation, the School is open to postgraduate students and research workers with a few years' experience in elementary particle physics, in computing or in related fields. The 80 or so participants will come mostly from CERN Member States or from laboratories closely associated with CERN, but a few may come from countries further afield. Applications (before 1 May) to Jacqueline Turner, School of Computing, CERN, 1211 Geneva 23, Switzerland Tel: +41 22 767 5049; fax: +41 22 767 7155; e-mail: Computing.School@cern.ch or via the Web: http://www.cern.ch/Physics/Conferences/C1997/CSC/

The European School of High Energy Physics (formerly the CERN-JINR School) was held last year from 1-14 September at Carry-le-Rouet, near Marseilles (October 1996, page 28). The 1997 school, organized by CERN, JINR (Dubna, near Moscow), and the Niels Bohr Institute, will be held at Naestved, Denmark, from 25 May - 7 June. The 100 or so participants will come mostly from CERN Member States or from laboratories closely associated with CERN, but a few may come from countries further afield. Information from http://www.cern.ch/PhysicSchool/ or Susannah Tracy, School of Physics, CERN/DSU, 1211 Geneva 23, Switzerland, phone +41 22 767 2724, fax +41 22 767 6760, E-mail Susannah.Tracy@cern.ch or Tatyana Donskova, International Department. Joint Institute for Nuclear Research, RU-141980 Dubna, Moscow Region, Russia, phone +7 095 926 2252/7 096 21 63448, fax +7 095 975 2381/7 096 21 65 891, E-mail donskova@ypr.jinr.dubna.su



A course on "RF Engineering for Accelerators", jointly organized by the CERN Accelerator School and its opposite numbers, KEKPAS in Japan and USPAS in the United States, attracted over a hundred students, mostly from Asia, to Shonan Village Centre, Japan. Here East meets West as Wolfgang Vinzenz gets to grips with a network analyser under the watchful eye of Fritz Caspers (CERN) and Tsutomu Taniuchi (Spring 8, Japan).

Servant of peace

Abdus Salam 1926-96

After being unable to communicate for the past three years by a crippling disease, Abdus Salam, world physicist and Nobel laureate, died on 20 November in Oxford.

In September 1956 a bespectacled 30-year old Pakistani physicist was returning to Cambridge, UK, from a physics meeting in Seattle. Instead of taking a scheduled flight, Abdus Salam boarded a US Air Force plane destined for a USAF base in England. In those days the US Air Force generously supported scientific research in European universities, and this support enabled physicists wishing to attend physics meetings in the US to take advantage of special flights for US servicemen and their families.

Although the European scientists were glad of the opportunity of cheap transatlantic travel, these flights were notoriously inconvenient and uncomfortable. Check-in meant travelling to a remote air base. Instead of tickets, there were 'flying orders', multiple copies which had to be successively surrendered at various stages of the journey. The planes were propeller-driven and laboriously slow, some fifteen hours to cross the Atlantic. The flights were frequently full of families with young children, noisy and excited about the prospect of moving from one country to another. The overnight west-east trip was particularly uncomfortable. But the European physicists appreciated this generous travel opportunity.

At the Seattle physics meeting, Salam had listened to Frank Yang explain his and Lee's ideas about weak interactions breaking mirror symmetry. Mrs. Wu & Co. had not yet embarked on their historic experiment, but Salam, receptive to innovative ideas, was prepared to believe what Lee and Yang were suggesting. As the US Air Force flight droned eastwards through the night, Salam's mind locked onto the problem. What could be special about the weak force to make it mirror sensitive?

Just a few months before the Seattle physics meeting, Fred Reines and Clyde Cowan had sent a telegram to Pauli in Zurich - 'We are happy to inform you that we have definitely detected neutrinos...'. After 25 years, Pauli's prediction of a bizarre particle which hardly reacted at all had been confirmed, and the Seattle meeting had heard the implications of this physics.

Thus neutrinos, as well as broken mirror symmetry, were very much on Salam's mind that airborne September night in 1956. 'I could not sleep,' recalled Salam. 'I kept reflecting why Nature should violate left-right symmetry in weak interactions. Now the hallmark of most weak interactions was Pauli's neutrino. While crossing the Atlantic, there came back to me a deeply perceptive question about the neutrino which Rudolf Peierls had asked me at my Ph.D. examination a few years before - "Why is the neutrino's mass zero?".' (Peierls later admitted that he did not know the answer to that question himself, but knowing Salam's reputation, he was interested in the reaction it would receive.)

In Arabic, abd-us-salam means 'servant of peace'. In 1949, the young servant had arrived at Cambridge as an aspiring research

student. However coming directly from Pakistan he had little knowledge of the new quantum electrodynamics ideas of Feynman and Schwinger. Assimilating these ideas in record time, he went on to apply them to other particles. With several landmark papers to his name and with a future in physics assured, in 1951 Salam nevertheless chose to return to Pakistan to become, at the age of 25, Professor at the College and University of Panjab, Lahore. Despite the local prestige of his new position, Salam found himself cut off from the excitement and continual stimulation of modern research. He realized this excitement was his lifeblood, and in 1954 left his native land to return to Cambridge, this time as a lecturer. Salam was only to stay at Cambridge for two years, but it was to there that he was returning from Seattle in 1956.

During that comfortless night in the air, Salam finally realized the answer to Peierl's trick question. In his cramped seat, Salam wrote down a

Salam receives his 1979 Nobel prize from the King of Sweden.

prototype neutrino equation using standard Dirac formalism. Dropping the mass term, he immediately saw that the remaining Dirac algebra could act like a switch - the neutrino could spin only one way but not the other. Salam realized that a zero-mass neutrino could be a miniscule corkscrew, drilling its way through space at the speed of light. Travelling at this speed, no other particle could overtake it, so there is no other vantage point to view the neutrino's spin. It would always appear to point the same way. A conventional right-handed corkscrew looks left-handed when reflected in a mirror, so a neutrino reflected in a mirror would no longer look like a neutrino - it would instead look like an antineutrino. Salam had realized that the neutrino, Pauli's ghost particle, was the culprit which broke the mirror of weak interactions.

The following morning, an elated Salam bustled off the plane and rushed as fast as he could to his Cambridge office, where he frantically calculated a few consequences of his new theory. Even more elated by the way everything seemed to be working out, he rushed onto a train to Birmingham, where Peierls lived, to say he now had the answer to the trick question posed a few years before.

Peierls' reply was typically kind but firm. 'I do not believe left-right symmetry is violated in weak nuclear forces at all.' With Mrs. Wu & Co. still assembling their epic experiment at Columbia University, Salam had knocked too early on Peierls' door. But the young Pakistani was insistent, and gave his neutrino paper to a physicist who was going to visit Pauli in Zurich. The reply soon came: 'Give my regards to my friend Salam

and tell him to think of something better'. Quashed, Salam hesitated before submitting his massless neutrino idea for publication. Four months later, on 24 January 1957, Pauli wrote again to Salam. Mrs. Wu & Co's result on the left-right asymmetry in cobalt decay had been published, and independent measurements had come in from Lederman and from Telegdi. Pauli changed his mind and Salam's ideas had been vindicated. Meanwhile Lee and Yang in the United States and Lev Landau in Russia had arrived at a similar conclusion about the neutrino and its mirror reflection.

Soon after formulating his neutrino theory, at the tender age of 31, Salam became Professor of Theoretical Physics at London's prestigious Imperial College of Science and Technology. With Salam's drive and ambition, Imperial soon became one of the world's leading centres in field theory.

As a researcher, Salam was always where the action was. Not for him the isolation of a research retreat. Seeing how physics was developing, Salam pushed Imperial theorists towards the problems of symmetry in particle classifications, and graduate student Yuval Ne'eman, at Salam's suggestion, explored the implications of group theory in particle physics, going on to arrive at parallel conclusions to those of Murray Gell-Mann's 'eightfold way'. Later, with Bob Delbourgo and John Strathdee, Salam explored how these internal particle symmetries could be welded with those of space-time.

The pinnacle of Salam's physics career came in 1979 when he shared the Nobel Physics Prize with Sheldon Glashow and Steven Weinberg for their unification of electromagnetism and the weak nuclear force in the 'electroweak' theory, a word invented by Salam in 1978. This unification was the outcome of an effort which had begun with Fermi but for Salam had commenced with a 1958 paper with John Ward and which went on to make Imperial College a focus for the study and applications of spontaneous symmetry breaking. In 1961-2, Weinberg and Salam, collaborating at long range with Jeffrey Goldstone, confirmed the prediction that massless 'Goldstone bosons' necessarily accompanied conventional spontaneous symmetry breaking.

A few years later, it was realized that these bosons do not apply to gauge theories, and a new route was discovered, a route now known as the higgs mechanism, which led in 1967 to the electroweak unification.

As well as his physics research, Salam worked tirelessly to further the cause of science in developing countries. Remembering vividly his own isolation when he had returned to his home country, in 1964 he founded the International Centre for

Physics monitor

Theoretical Physics in Trieste, Italy, now a world-class research establishment, where promising young scientists from all over the world get a taste of front-line research early in their careers.

Salam's deceptively soft, husky voice masked an iron will and ruthless ambition. He could be arrogant, but also used argument as a intellectual weapon to prise open a difficult problem or seek new ideas. A consummate international, he was equally at home with P.G. Wodehouse or the Koran.

Despite being the only Pakistani to have won a Nobel Prize, and despite his impressive international achievements, Salam's position in his home country was ambivalent. Under the powerful rule of Ayub Khan, Salam once wielded considerable influence. However as a member of the minority Ahmedi Islamic sect, he resigned his influential position as chief scientific adviser in 1974 when Pakistan's National Assembly under Zulfikar Ali Bhutto excommunicated the Ahmedis from Islam. The Ahmedis claim that Mirza Ahmed, born in Qadian in northern India in the late 19th century, was the Mahdi, or Messiah, a view which is sacrilege to conventional Islam. Mainly confined to Pakistan, India and East Africa, the small Ahmedi sect is a frequent target of intolerance and discrimination, both from the religious orthodoxy and the mass of people. In 1979, after the announcement of his Nobel award, Salam was initially invited to Pakistan by General Zia ul-Haq, but other pressures soon blew an icy wind of excommunication.

With Salam stricken by illness, at Trieste it became clear he could not function much longer as the Institute's Director. As a tribute to its founder, which he would be still able to appreciate before his powers waned completely, in 1993 the centre organized a three-day physics meeting which was attended by colleagues, admirers and former students from all over the world. One was Frank Yang, whose talk on mirror symmetry in 1956 had so much impressed the young Salam.

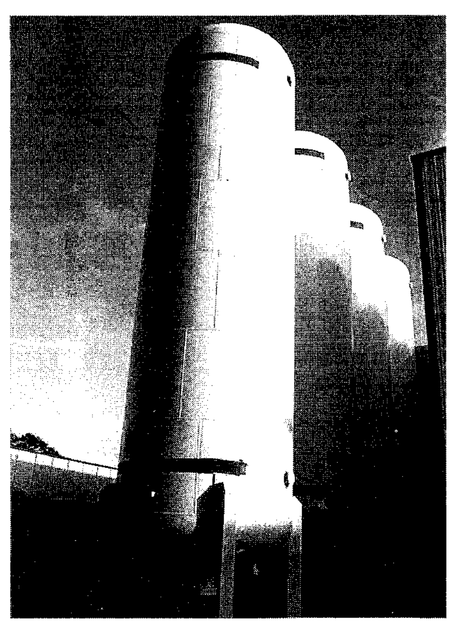
The culmination of the meeting was the award of an honorary degree of the University of St. Petersburg, Russia. The rector of the University made the trip specially. Salam listened from his wheelchair but could not speak. After the formal ceremony, participants stood patiently in line to offer their own congratulations. There was little response from Salam, but all hoped their message was getting across.

After famous names, it was the turn of younger students. One of the last was a nervous young man from Pakistan, a young researcher who had succeeded in gaining one of the highly-prized scholarships to Salam's centre. As he bent towards Salam hunched in his wheelchair, he said 'Sir, I am a student from Pakistan. We are very proud of you.' Salam's shoulders shook and tears ran down his face.

A cold welcome

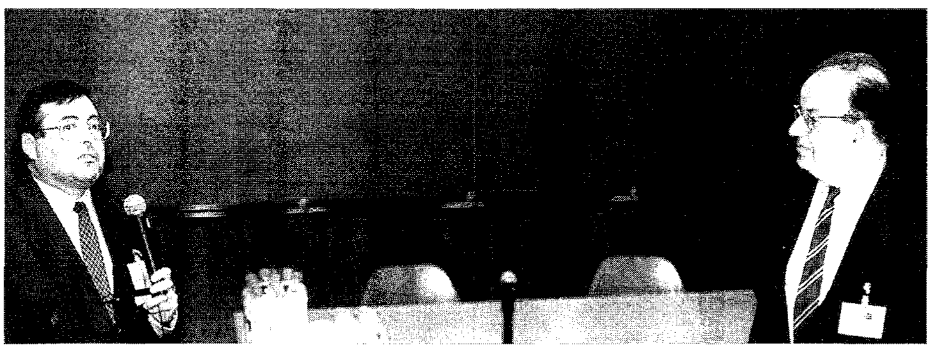
Cryogenics is one of the big technological success stories of particle physics, and it was fitting that CERN recently hosted an International Symposium on Cryogenics in Industry which attracted specialists from all walks of cryogenics life.

For particle physics, low temperature equipment was first needed on a large scale for Luis Alvarez' pioneer big liquid hydrogen bubble chambers in the late 1950s. For subsequent developments, cryogenics has been frequently, but not always, synonymous with the improved performance provided by superconductivity, particularly the high magnetic fields provided by superconducting magnets. For bubble chambers, demand for cryogenic plant increased with the advent in the late 1960s of large detectors equipped with superconducting magnets, where the



Large-scale cryogenics for CERN's LEP electron-positron collider - liquid helium reservoirs from Russia.

A cold welcome. At the opening of the recent International Symposium on Cryogenics in Industry at CERN: Organizing Committee Chairman Philippe Lebrun of CERN (left) with Bernard Hébral, Chairman of Commission A 1/2 of the International Institute of Refrigeration.



12-foot chamber at Argonne was subsequently upstaged by BEBC at CERN and the 15-foot chamber at Fermilab.

A new horizon opened with the construction of Fermilab's Tevatron with its four-mile ring of superconducting magnets. Superconducting magnets had been used in beamlines, in low-beta insertions to squeeze colliding beams, and in spectrometers, while research and development work had led to revolutionary new types of filamentary conductors which went on to make a major impact on this technology. But the Tevatron, with a thirst for 5000 litres of liquid helium per hour, blazed a new trail and was the first industrial-scale cryoplant at a particle physics laboratory. Subsequently, the 6.3 kilometre HERA proton ring at DESY Hamburg and the CEBAF recirculating linac arrangement at the Jefferson Laboratory, Newport News, Virginia, swelled the ranks of big superconducting magnet rings.

Subsequently, the high magnetic fields required for the new generation of colliders, such as RHIC at Brookhaven and the LHC at CERN, can only be supplied by superconducting magnets - conventional magnets being limited to fields of about 2 tesla. In addition, superconductivity gives considerable savings in power - about 6 MW is needed to cool the 800 GeV HERA proton ring, while on average several times this figure is needed to drive the CERN SPS synchrotron at 450 GeV.

While protons are heavy and 'stiff' proton beams need lots of bending effort, electrons are very light and the beams pliable. However electron beams lose a lot of energy due to synchrotron radiation as they are bent, so that electron rings are therefore are hungry for input power. For protons, the superconducting spotlight falls on magnets to guide the beams, while for electrons the superconducting goal is more on accelerating power.

Development work to harness the efficiency of superconductivity to drive radiofrequency cavities began at Stanford University (in the context of a linear accelerator) where electrons were first accelerated in a superconducting resonator in 1965. By the 1980s cavities had been installed at several electron machines and major programmes were underway at Cornell, CERN, KEK (Japan), CEBAF/Jefferson....

To increase its energy, CERN's 27-kilometre LEP electron-positron collider is being fitted with superconducting accelerating cavities, a scheme launched by the far-sighted John Adams back in 1979, and the associated cryogenic plants will be capitalized for the LHC proton collider to be built in the LEP tunnel.

Introducing the cryogenics conference proper, Oscar Barbalat of CERN looked at the impact of 'megascience' - as defined by the Organization for Economic Cooperation and Development - on cryogenics and applied superconductivity. While installations in many physics areas use cryogenics and superconductivity on a large scale, Barbalat still saw the move from megascience to industrial technology as a major obstacle.

Jorg Schmid of CERN sketched the use of cryogenics in particle accelerators, both for bending and focusing magnets and for the radiofrequency accelerating cavities.

Giorgio Passardi of CERN outlined the wide range of cryogenic options now in use in detectors for particle physics experiments. As well as the advent and demise of the cryogenic bubble chamber, polarized target requirements had also helped to introduce cryogenics to the particle physics scene. For large detectors, cryogenic requirements are centred around spectrometer magnets and calorimeter technology.

One of the best known major cryogenic applications area for physics is in the big push to control thermonuclear fusion, where superconductivity is indispensable for the next generation of containment machines. Bernard Turck of the French Atomic Energy Commission's Cadarache centre described the French Toresupra, the German W7X Stellarator and the ITER international scheme, requiring respectively 35, 45 and 1200 tonnes of superconductor.

Another major outlet for superconducting magnets is for magnetic resonance imaging, mainly

Imperial College of Science Technology and Medicine, Department of Physics, South Kensington, London SW7

Two post doctoral Research Associates

Applications are invited for two PPARC-funded two year posts to join the UK collaboration searching for the direct signatures of the dark matter of the Universe, in the form of new, Weakly Interacting Massive Particles (WIMPS). The experiments are being deployed in the Boulby mine, N. Yorkshire and the posts are both connected with the development of liquid Xe scintillation detectors to achieve higher sensitivity to dark matter signals.

Post 1 is to be initially at ICSTM with visits to Boulby envisaged later. The post holder will assist in the building and commissioning of prototype Xe chambers. Knowledge of cryogenic and/or nuclear counting techniques is desirable.

Post 2 is to be mainly located at the Rutherford Appleton Laboratory, near Oxford but in close collaboration with ICSTM and also involving experimental work at Boulby Mine. It will involve design and production of a background veto system and other design and analysis work related to the Xenon experiment. Experience in both particle counting techniques and computer skills are required.

The candidates will join an established team and there are reasonable prospects of extension of the posts beyond the two years.

Salary in the PPARC 1A range. Closing date, March 15. Posts available from April/May, 1997. Send CVs and the names of two referees or requests for further details to Dr W.G. Jones tel. 0171 594 7805 or Dr J.J. Quenby tel. 0171 594 7527 Department of Physics, ICSTM, Prince Consort Rd. London SW7 2BZ, UK.

Max-Planck-Institut für Kernphysik
Postfach 103980, D-69029 Heidelberg

The Max-Planck-Institute in Heidelberg, offers a

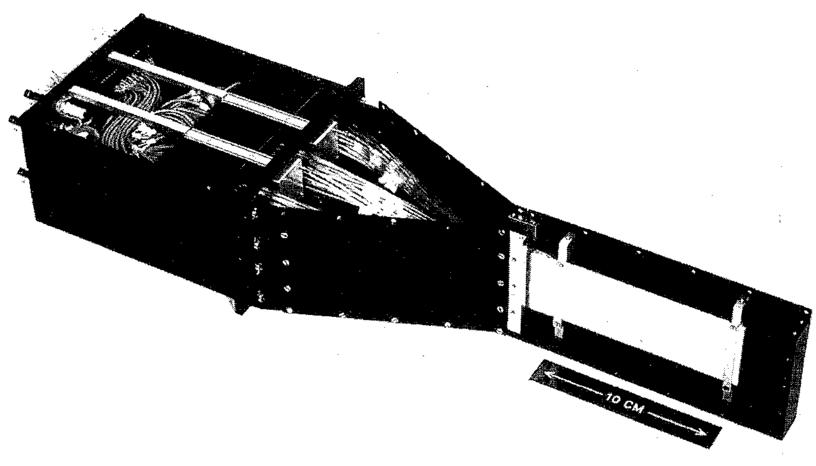
Postdoctoral Position

for the project HERA-B in the group of Prof. Dr. W. Hofmann. The goal of the HERA-B experiment is the first observation of CP-violation in decays of B-mesons. The MPI Heidelberg is involved in the construction of the silicon vertex detector, which is placed inside a vacuum tank in order to achieve the best possible resolution for secondary vertices. The successful candidate will participate in the construction and comissioning of the vertex detector and in the analysis of the HERA-B data.

The applicant should have a university degree with a Ph.D. in experimental high energy physics, hardware experience as well as knowledge in on-line computing, data analysis and Monte-Carlo simulation.

The position will be free from May 1st, 1997. The contract will initially be for 2 years, with possible extension to 5 years, and a salary according to BAT IIa. Handicapped applicants will be given preference to others with the same qualification. Applications should be sent under Reference 03/1997 to *Max-Planck-Institut für Kernphysik, Personalverwaltung, Postfach 103980, D-69029 Heidelberg.*

Generic prototype of a scintillating-fibre detector for the DIRAC pionic atom experiment at CERN. The design uses a modular position-sensitive photomultiplier (PSPM) housing structure accommodating 48 channels. As well as making for flexibility in the final size of the full detector, this also allows a rapid repair or exchange of defective modules or PSPMs..



for medical tomography, where David Hawksworth of Oxford Magnet Technology pointed out that since the introduction of this technology in the early 1980s, the market has grown to some 12,000 installations worldwide. For the future, René Flückiger of Geneva described the impact of new superconductors.

Summarizing the status of particle physics at the meeting, Pierre Darriulat of CERN drew attention to the need for low temperature detectors, especially in spaceborne experiments, to make precision measurements.

As well as these major scientific areas, more specific projects were covered in brief oral presentations and poster sessions, while the parallel industrial exhibition attracted considerable interest. But the real star of the show was CERN's own installations, cryogenic and otherwise. The delegate tours of the Delphi experiment at the LEP, electron-positron collider, the superconducting magnet and cavity test area and the central cryolab were fully booked.

DETECTORS Scintillating fibres at work (1)

To help in the search for rarer physics events, one emerging trend is to pull together more precise information on the pattern of produced particles early in the event selection process. This requires a detector which assures not only good space and time resolution while acting as such a topological trigger, but also a simple and reliable means of handling the position information in real time.

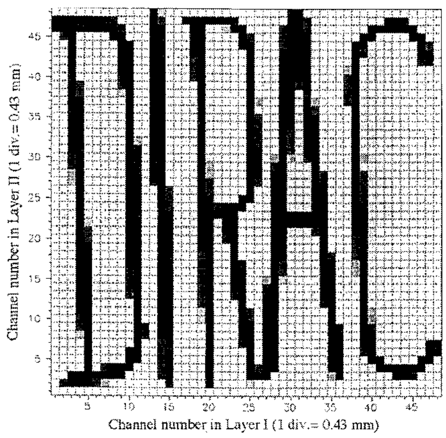
To meet this demand, a scintillating-fibre detector is in preparation for the 'DIRAC' (DImeson Relativistic Atom Complex) experiment at CERN's proton synchrotron based on the technical achievements of RD17 research and development project - fast readout of scintillating fibres using position-sensitive photomultipliers (PSPM). The technique fully profits from the advantages photomultiplier technology developed over the last several decades.

The unusual DIRAC experiment sets out to measure pion-pion scattering by synthesizing atoms consisting of a positive and a negative pion rotating round each other. Precision measurements of the lifetime of these atoms will reveal new information on pion-pion interaction, vital to test emerging ideas in quark-gluon field theory (quantum chromodynamics - QCD).

For the experiment, a generic prototype with 96 channels, corresponding to a fifth of the full detector, has recently been produced and successfully tested by a LAPP(Annecy)/CERN/ IHEP/Kyoto-Sangyo/Trieste/UOEH/Waseda team. It is based on a new series of PSPM, H6568 from Hamamatsu Photonics, followed by specially designed front-end electronics and a peak-sensing circuit (PSC), which digitizes the track position in real time by suppressing annoying cross-talk between adjacent channels.

With an array of 0.5 mm diameter fibres, the space resolution for individual minimum ionizing particle 'hits' is about 130 micron with a detection efficiency higher than 95 %. Double tracks were also detected with a minimum two-hit separation of about 0.4 mm. As required for the DIRAC experiment, the distance between two tracks was successfully digitized in real time with a simple logic circuit. The time jitter of signals through the electronics (PSPM + PSC) was less than 500 ps. A finer or coarser granularity of detector elements could be achieved by using fibres of appropriate diameter without any major modification of the present setup.

With proven photomultiplier technology, such a device could have a wide range of ongoing applications for high-luminosity experiments.



A two-dimensional image of particle hits passing through a beam counter provided with a mask in the form of tiny pieces of scintillator in the shape of letters. Such fine pixel granularity of 0.43 x 0.43 mm² is difficult to achieve using conventional photomultipliers.

Scintillating fibres at work (2)

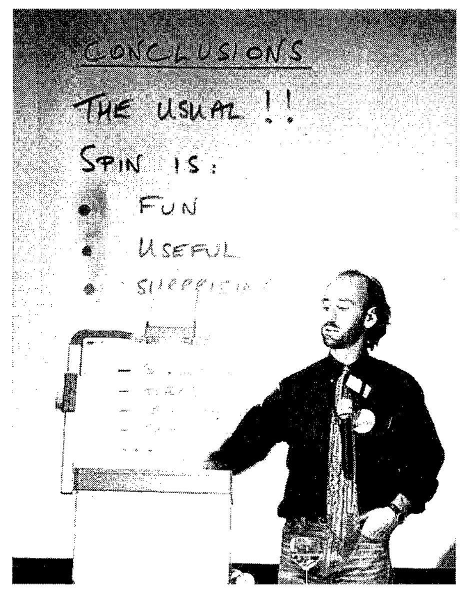
In another development for a position-sensitive photon detector using scintillating fibres, the RD7 research and development collaboration at CERN has produced an imaging silicon pixel array tube, in which the phosphor screen of a conventional image intensifier is replaced by a multi-anode chip (developed in turn by the RD-19 group). This technique sidesteps the degradation usually associated with using image intensifiers to read out scintillating fibres. Another team, RD-46, is investigating the potential of arrays of 20 micron capillaries filled with liquid scintillator. The biggest ongoing application remains the scintillating fibre tracker of the Chorus neutrino experiment at CERN, containing in total some 2,600 kilometres of fibre.

Spin physics symposium

Summarizing the 12th International Symposium on High Energy Spin Physics, held in Amsterdam from 10 - 14 September, Phil Ratcliffe (Como) said that spin physics has now definitely come of age. This is evident from the wealth of experimental and theoretical results - accurate determination of structure functions, accurate electroweak measurements and sophisticated calculations within the framework of perturbative Quantum Chromodynamics (QCD). Tremendous progress was also reported in the polarization of beams and targets.

The meeting's 300 participants were welcomed by incoming chairman of the International Committee on High Energy Spin Physics, Charles Prescott of SLAC, who takes over from Brookhaven's Alan Krisch. John Ellis of CERN set the tone of the conference with a discussion of the spin aspects of violent scattering, where a projectile penetrates deep inside a target nucleon. Ellis paid particular attention to the momentum distributions (structure functions) of constituents with different spin polarizations inside the proton.

In 1987, the European Muon Collaboration at CERN found that the proton's spin is not all accounted for by the individual angular momentum and individual spins of the quarks, and a large fraction must be due to something else (see page 3). Since then, measurements have shown that only about 25% of the proton's spin is carried by quarks, and physicists now believe that much of the remaining spin must be due to the gluons which hold the proton together, and to angular momentum of quarks and gluons.



Spinning summary. Phil Ratcliffe (Como) wraps up the 12th International Symposium on High Energy Spin Physics, held in Amsterdam.

John Collins (Penn State) gave a broader discussion of mostly theoretical aspects of violent scattering within the context of QCD. He emphasized that while a great deal is now understood about the hard-scattering parts (treated with perturbative methods), ways for understanding the non-perturbative (soft) parts are still urgently needed.

Gerd Mallot (CERN) and Stefano Forte (Torino) gave respectively experimental and theoretical overviews of the spin structure function for protons and neutrons. Polarized scattering data are becoming very precise and cover an interesting kinematic range.

One important sum rule due to Bjorken relates the difference between the proton and neutron structure functions to basic weak interaction parameters obtained from neutron (beta) decay. With this fundamental relation now verified to a

Chairman of the spin symposium organizing committee Kees de Jager (right) with new chairman of the International Committee on High Energy Spin Physics Charles Prescott of SLAC (centre) and outgoing president Alan Krisch of Brookhaven.

few percent, it is customary to impose the relation and extract other quantities, such as a value for the strong coupling constant that is remarkably competitive with other measurements.

Studies of the behaviour of the structure functions at small momentum fraction (x) will help to disentangle subtle effects. Two years ago, at the 11th symposium in Bloomington, the general view was that quarks contribute about one third of the proton spin, while now the first indirect evidence for gluon contributions is becoming evident. Several other talks discussed experiments to directly measure this effect, including forthcoming studies at Brookhaven and at CERN (COMPASS experiment).

The large gluon contribution to the proton spin must be accompanied by orbital angular momentum of quarks and gluons. Xiangdong Ji (MIT/ Maryland) gave an enthusiastic and clear account of how to handle quark orbital angular momentum.

Another subject of great interest was single-spin asymmetries, notably those in hadron production in proton-proton collisions. Ken Heller (Minnesota) reviewed the production of hyperons, in which the asymmetries display many regular features in their kinematic dependence, but with some puzzling exceptions. A related quantity is the sizable left-right asymmetry in pions produced in polarized proton-proton scattering.

The use of weak interactions in the search for physics beyond the Standard Model was discussed by Mike Musolf (Seattle). The weak interactions, in particular the different couplings to left-handed and right-handed quarks, and the difference between the coupling to quarks and that of the photon, can also be used to investigate the spin of the nucleon.

Betsy Beise (Maryland) indicated how experiments at moderate energies (e.g., SAMPLE at MIT/ Bates) provide the first indications for a small and positive strange quark contribution to the magnetic moment of the nucleon. Theoretically the estimates for this contribution, though widely varying, are generally negative.

Desmond Barber (DESY) described progress with polarized beams, where in the future 80% polarized positron beams may be possible at HERA. An example demonstrating the day-to-day importance of spin is the use of polarized beams at LEP, providing precision energy calibration.

Yousef Makdisi (Brookhaven) and Hideto En'yo (Kyoto) described developments at Brookhaven's RHIC heavy ion collider (March 1996, page 19), indicating the possibilities of measuring such quantities as the gluon polarization in the proton and the separation of the various different quark contributions, stressing the complementarity to experiments using electron beams at CERN, SLAC (Stanford), HERA (DESY, Hamburg) and CEBAF (Newport News, Virginia).

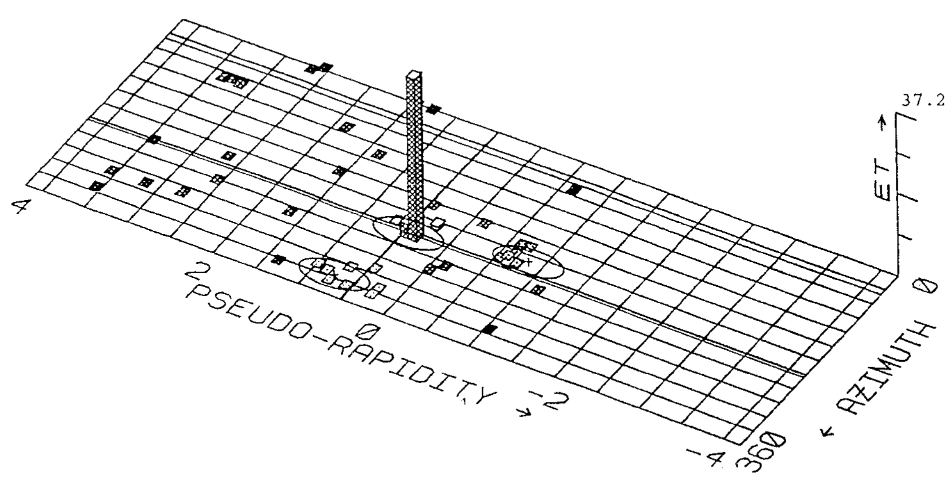
Results of the SLD experiment at Stanford's SLC linear collider were presented by Richard Prepost (Wisconsin), who emphasised the polarization role of the machine. Measurements of lepton asymmetries contribute decisively to an increased precision in the determination of the vital electroweak mixing parameter. Prepost also discussed the importance of Cherenkov Ring Imaging Detectors in heavy quark measurements.

Steve Vigdor (Indiana) summarized possible tests of symmetry principles in medium-energy hadron physics, including violation of time reversal symmetry in an experiment under consideration at COSY in Jülich, or charge symmetry breaking effects in nuclear forces. Jo van den Brand (Amsterdam) discussed how dedicated experiments can address questions such as the role of relativistic corrections and three-body forces in the quantum mechanical description of light nuclei.

The meeting drew 300 participants, with 15 plenary presentations and 5 rapporteur talks of workshops sponsored by the International Committee on High Energy Spin Physics. In addition, there were about 150 contributions to the afternoon parallel sessions, covering aspects of both nuclear and particle physics. Round-table discussions, were organized by Yuri Arestov (Moscow) on RAMPEX, a new spin experiment with 70 GeV protons at the Russian IHEP centre at Serpukhov, near Moscow, and another by Vernon Hughes (Yale) on the gluon spin distribution.

The next symposium in the series will be held in Protvino (Russia) in September 1998.

From Piet Mulders



Display of a candidate diffractively produced W-boson in the CDF experiment at Fermilab's Tevatron proton-antiproton collider. Such Ws are produced by quark-antiquark annihilation and subsequently produce an electron and an undetectable neutrino. In this case, the antiquark comes from a pomeron rather than the antiproton.
The calorimeter measures energy in cells of azimuth angle and pseudorapidity (a measure of the polar angle). Hit cells are plotted as "towers" whose height is proportional to the transverse energy deposited. This event shows one tower with electromagnetic energy deposit of 42 GeV with no detected balancing particles, a clear sign of a W-boson (the accompanying neutrino cannot be detected). Three units of pseudorapidity, from -1.2 to -4.2, are seen to be empty, and other detectors (not shown) extend this "rapidity gap" to -5.9. A quasi-elastically scattered 'spectator' antiproton was detected at a pseudorapidity of -7 units.

Gaps in understanding

Despite the unlikely title of Small-x and Diffractive Physics, a four-day workshop sponsored by Argonne National Laboratory and Fermilab recently held at Argonne focused attention on the understanding of the strong inter-quark force, and in particular its vacuum structure.

The elegant theory of the inter-quark force, called Quantum Chromodynamics or QCD, is in many ways similar to electromagnetism, but with essential differences which ensure that quarks remain permanently bound inside their parent nucleons and do not emerge as free particles. The messengers of the inter-quark force are gluons, which carry 'colour', analogous but very different to the familiar electric charge of electromagnetism. In particular the visible particles, such as protons or neutrons, have no net colour - are 'colourless' - and this simple requirement underlies the observed gamut of different particle states.

Hundreds of tests of QCD have been made and it has never yet been found wanting, so we have come to believe that it is THE theory of strong interactions. However we only know how to make reasonably accurate QCD calculations in certain special circumstances, typically when masses or the momentum exchanged in a reaction are large.

In practically all the interactions that occur at Fermilab's Tevatron proton-antiproton collider this is not the case, and we are unable to calculate with QCD the probabilities for common reactions, such as elastic scattering where the proton and antiproton simply emerge deflected. In this simplest case some momentum is transferred from one beam particle to the other, and whatever carried the momentum must have been colourless (or the protons could not have remained so).

The most likely suspect, proposed in 1975, is a colourless two-gluon composite. Before the gluon era, this is what had been traditionally called the "pomeron", after the Russian physicist Isaak Jakoblevich Pomeranchuk. However in QCD it does not make sense to say that the pomeron is exactly two gluons, because the gluons will be exchanging more gluons between themselves as well as virtual quark-antiquark pairs. Such effects are incorporated in a modern version of the two-gluon pomeron called the BFKL pomeron after the initials of its four main originators (Balitsky/Fadin/Kuraev/Lipatov).

The pomeron is rather special in that is has the same quantum numbers as the vacuum (apart from its spin which is a complex issue). What is the relation between the pomeron and the vacuum? Both might be considered as nothing - the ultimate in simplicity, but from another point of view the ultimate in continuously variable quantum complexity, seething with fluctuations as particle-antiparticle pairs of all types (electrons, quarks, gluons, etc.) are created and annihilated. These transient particles are hard to detect, but their effects do show up in some experiments. A vacuum is definitely not "nothing".

Moving from the complexity of nothing to that of a physical particle, its constituent quarks and gluons themselves hardly have any well defined identity. They are continually changing colour, emitting and absorbing gluons; gluons can meta-morphose into a quark-antiquark pair, antiquarks can annihilate with quarks to make gluons, etc.

The "inside" of protons and all other strongly interacting particles is continually boiling with activity, like the surrounding vacuum. Another degree of complexity is exemplified by the maxim "the harder you look, the more you see". This means that as the proton is probed with photons of ever decreasing wavelength, an initial fuzzy blob gradually resolves into three quarks, which then dissolve into more and more quarks, antiquarks and gluons.

If the proton is moving with a momentum p, these "constituents" each have momenta xp, so that the sum of all the momentum fractions x equals 1. For small probe wavelengths, with high resolving power, we see a rapidly increasing density of gluons as x gets very small, less than 0.0001. Such an increase cannot continue indefinitely. Presumably this low-x gluon cloud will ultimately become so dense that pairs of gluons will start recombining, as if a branching tree were to develop a surrounding net where the densely packed twigs fuse together.

The higher gluon density at low x is intimately related to the pomeron and in turn to the rise of particle interaction probabilities with energy.

The experimental study of the pomeron took an important upturn in the last three years with experiments at the Tevatron and at DESY's HERA electron-proton collider. At the Tevatron's CDF and D0 experiments, the main progress has been through studies of two closely collimated sprays or 'jets' carrying high transverse energy, known to result from hard quark or gluon scattering, accompanied by what are call 'rapidity gaps'.

Rapidity gaps are large angular regions where no particles are produced, and are known to result from pomeron exchange, which cuts an otherwise uniformly populated angular region into distinct zones. The rapidity gap can be between the two jets, in which case the pomeron carries a very large momentum transfer, or to one side. In the latter case it seems that the scattering quark or gluon comes from the pomeron, and by measuring the jets one can probe the constituent structure of the pomeron.

The first data on jets produced in pomeron interactions came from Experiment UA8 at the CERN proton-antiproton collider (March 1992, page 4). CDF also has evidence for W-bosons produced in this way, where one beam particle scatters almost elastically and the accompanying pomeron interacts with the other particle to make a high mass state. Comparing W and jet production reveals the fraction of gluons and quarks in the pomeron.

Experiments UA1 and UA8 at the CERN Collider and now CDF and D0 at the Tevatron have evidence for jet production with two forward rapidity gaps, interpreted as pomerons colliding, with the pomeron constituents supplying the jets.

The experiments at HERA, ZEUS and H1, are complementary, colliding electrons and protons. The electrons radiate photons which probe the proton with wavelengths much smaller than the proton size. Some 10% of their events have the proton emerging almost elastically, and these can be interpreted as the proton emitting a pomeron; this pomeron is then probed by the electrons' photons.

Being an electromagnetic quantum, the photon probes directly the charged constituents of the pomeron, and is blind to the strongly-interacting gluons which have no electric charge. However by measuring the pomeron quarks and observing how their distributions change with photon wavelength one can infer the pomeron's distribution of gluons.

A remarkable, and still perhaps controversial, result from H1 was their conclusion that at "long" wavelengths ($Q^2 = 5$ GeV^2 for experts) the pomeron seems to be mostly a single gluon! As the wavelength decreases this "evolves" by emitting other gluons and quarks into more constituents with a more democratic distribution of momenta.

While in certain circumstances the pomeron seems to behave dynamically like a single gluon, we know that cannot be the whole story because the gluon carries colour and the pomeron has to be colourless. We are led to suppose that the gluon colour is compensated by something "soft", e.g. that the pomeron, at short wavelengths, is one gluon carrying most of the pomeron's momentum and another one or two gluons carrying very little. As the wavelength decreases (better resolving power) the pomeron becomes a more democratic mixture of gluons and quarks, sharing the momentum more equally.

This seems to fit the observations, although a lot more data are needed to be sure. This picture of the pomeron raises some very interesting theoretical issues which may have profound consequences for our understanding of the strong force. Much more work, theoretical as well as experimental, is needed before we know whether these ideas are correct. One conclusion was however clear: this field is now very active, with exciting new data from the Tevatron and HERA and much theoretical progress. We do not yet have a coherent picture of the pomeron which describes all the data and makes testable predictions, but a better understanding of this vital aspect of 'nothing' remains a major goal.

From Michael Albrow and Alan White

Desperately seeking unseen SUSY

For twenty years, SUSY - or supersymmetry - has been the heartthrob of theoretical physicists. The widespread conviction that SUSY will solve many of their problems has spilled over into the experimental sector, but despite hunting high and low, no sign of SUSY has been seen.

Strictly speaking, SUSY is no Standard Model. Today's Standard Model takes the electroweak picture, unifying electromagnetism and the weak nuclear force, in tandem with the field theory of quarks and gluons (quantum chromodynamics - QCD).

This shotgun wedding between the electroweak picture and QCD has never been comfortable, but a better match requires a considerable dowry in the form of a unification scale of some 10^{15} GeV, very different to the 100 GeV or so of the electroweak picture, itself a major step from the zero mass photon.

What is behind this immense staggering of mass scales from one unification to the next? The hope is that SUSY can bridge these mass chasms and make the successive unification pictures more assimilable. But the price is a doubling of the number of particles.

The chessmen of particle physics come in two kinds, the quarks and leptons. 'Messenger particles' - photons, Ws, Zs and gluons - move the chessmen around on the board. Quarks and leptons are 'fermions', obeying the Pauli Exclusion Principle, so that not more than one particle can occupy any one square on the quantum chessboard. On the other hand the messenger particles are 'bosons' and have no such quantum accommodation restrictions.

SUSY demands that for every known particle, there is a supersymmetric partner - each fermion has a boson 'spartner', and vice versa. Quarks pair with 'squarks', and leptons with 'sleptons', while the Standard Model bosons pair with 'charginos' and 'neutralinos'. SUSY's appeal is so compelling that some enthusiasts have repackaged the Standard Model accordingly.

The lightest (and most stable) of these additional SUSY particles also provide a potential source of 'dark matter' - the invisible material which we nevertheless know must be there to account for the observed motion of galaxies. Is this intangible dark matter the same as the unseen SUSY?

With the spectrum of unification mass scales so large, SUSY particles can sit anywhere in a mass ladder extending anywhere from some 50 to 1000 GeV (the heaviest known particle, the top quark, has a mass of some 175 GeV). These masses extend beyond the scale currently accessible to laboratory experiments. However experiments at CERN's LEP electron-positron collider and Fermilab's Tevatron proton-antiproton collider have explored the lower energy fringe of the available SUSY territory. At LEP, one SUSY sector has been ruled out below 80 GeV, while at the Tevatron another sector is excluded below about 200 GeV.

A special meeting at CERN on 30 October examined the SUSY discovery potential of the experiments at CERN's new LHC proton-proton collider. The conclusion was that LHC could find SUSY up to some 400 GeV for sleptons, some 2000 GeV for squarks and gluinos, and probe the lightest supersymmetric particles up to some 350 GeV, covering almost the full allowed range. Despite the cluttered conditions of 14 TeV proton-proton collisions, the expected SUSY signals should be visible. The experimentalists are convinced that if SUSY is not just a dream, then the LHC will reveal all.

FERMILAB First antihydrogen

Experimenters at Fermilab have produced and detected atoms of antihydrogen using a gas-jet target in the Antiproton Accumulator. This confirms results announced last year (March 1996, page 1) at CERN. Both the CERN and Fermilab antihydrogen experiments used an idea proposed by Charles Munger, Ivan Schmidt, and Stanley Brodsky in 1992. A fast-moving antiproton passing an atomic nucleus can create an electron-positron pair; in rare instances, the positron will stick to the moving antiproton to make an atom of antihydrogen. Fermilab's higher-intensity and higher-energy antiproton source open up higher antihydrogen yields.

A key to the success of these experiments is the gas-jet target, using a design developed by Mario Macri and Mauro Marinelli at Genoa University and INFN.

Matter symmetry

The CPLEAR experiment at CERN's Low Energy Antiproton Ring, LEAR, has just completed its final run.

The delicate violation of 'CP symmetry' - changing particles to antiparticles and reflection in three-dimensional space - appears to play a fundamental role in the order of things. Thirty years after its discovery, it is still not understood.

Looking-glass particles

In any recipe for particle interactions, take a particle, replace it with its antiparticle, look at it in the mirror, and reverse its direction in time. The result, according to the famous CPT symmetry theorem, should be indistinguishable from the original. This apparently abstract idea has profound philosophical and down-to-earth implications which the CPLEAR experiment at CERN's Low Energy Antiproton Ring, LEAR, has been probing for a decade. After using an impressive 10^{13} antiprotons, the experiment has just completed its final run.

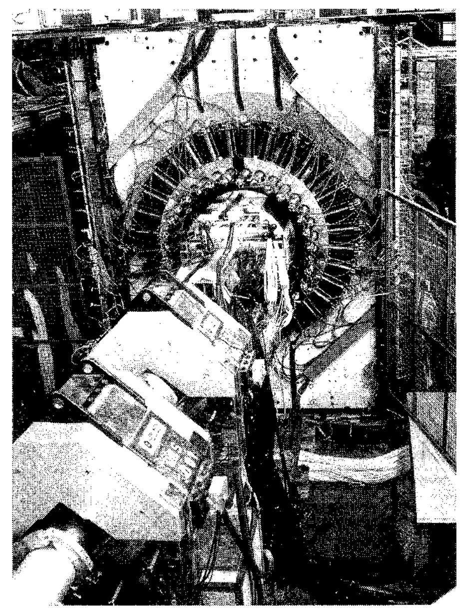
C, P, and T

C, P, and T are vital test symmetries of particle interactions. C, charge conjugation, represents replacing a particle by its antimatter counterpart. P, parity, corresponds to looking in a mirror which reverses not just one but all three spatial co-ordinates, and T is time reversal. If a symmetry does not effect the outcome of an interaction, then that interaction is said to conserve the symmetry.

Each of C, P, and T was once thought to be conserved in all interactions. We now know this is not the case. In fact non-conservation of the CP combination could help to explain why there are three families of particles, and why there is any matter in the Universe to make stars, planets, and human beings. On a more esoteric level, despite the observed CP violation, current theory demands that the CPT combination be conserved. Any hint of CPT violation would send particle theorists back to the drawing board. CPT conservation implies that T must be violated to cancel out CP violation. In other words, an antiparticle is indistinguishable from a particle moving backwards in time.

In the electromagnetic and strong interactions, each of C, P, and T appears to be conserved, and this was once believed to be true for the weak interaction as well. However, the world of physics was startled in 1956 when T. D. Lee and C. N. Yang concluded from a survey of available data that P might not be conserved in weak interactions. They based their conclusion largely on the fact that particles called kaons had been observed to decay into two different final states which have opposite parities.

Nor does the weak interaction conserve C. The weakly interacting neutrino spins left-handedly, and the operation of charge conjugation would produce a left-handed antineutrino, a particle which does not exist in nature's kit of parts. The combination of C and P, however, produces a right-handed antineutrino, which does exist. Physicists hoped that the CP combination would be conserved in weak interactions, but in 1964, James Cronin and Val Fitch demonstrated at Brookhaven that CP

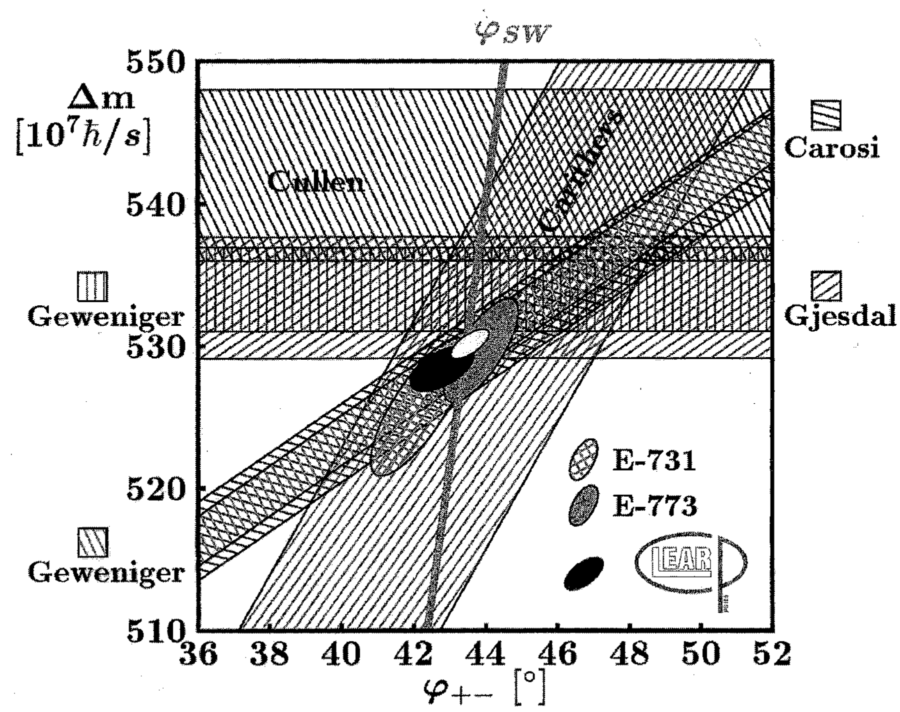


is violated in neutral kaon decays at the level of a fraction of a percent.

In 1973, after Nicola Cabibbo had described how to look at weak decays of the kaon, Makoto Kobayashi and Toshihide Maskawa showed how CP violation could be accommodated in the Standard Model by increasing the number of particle families from the two known ones to three or more. This idea began to look very attractive with the discovery of the bottom quark, lightest member of a third quark family, by Leon Lederman's group at Fermilab near Chicago in 1977. Ever since, the quest has been on to measure CP violation in the kaon system precisely.

Brief history of universe

The reason for all the excitement about CP violation goes back to the Big Bang itself. Matter and antimatter are believed to have been created in equal amounts, but today there appears to be only matter.



Measurements of the mass difference between long lived and short lived kaons and the CP-violating phase angle are dominated by CPLEAR results (dark area), and agree precisely with the theoretical prediction.

Science fiction is fond of anti-worlds, whose inhabitants seem identical to the inhabitants of ordinary matter worlds. There is a perfect symmetry between the two, and when anti-man meets ordinary man, the two annihilate leaving behind nothing but energy, largely in the form of photons. If this scenario were really true, then all the matter and antimatter created at the Big Bang should have disappeared in this way, leaving behind a Universe full of photons. Clearly this is not the case, but it is very nearly true. There are about a billion photons in the Universe for every proton, or put another way, nature's interactions have curiously allowed one proton to survive for every billion to have annihilated with antiprotons.

In 1966, the Russian physicist Andrei Sacharov defined three conditions necessary for this imbalance to arise. The first says that protons can not be absolutely stable, they must decay with a lifetime which he estimated to be about 10^{55} years. This means that for all the protons in the Earth, fewer than a bread crumb's worth should have decayed so far. The second requires the Universe to have passed through a period of thermal disequilibrium, and the third brings us to CP violation. It states that there must be some fundamental difference in the way nature treats matter and antimatter.

Sacharov's third condition requires the CP combination to be inexact, as demonstrated by Cronin and Fitch. This is because if CP symmetry were exact, then the matter-to-antimatter asymmetry would precisely cancel the antimatter-to-matter asymmetry.

The neutral kaon system

Apart from the matter-antimatter imbalance of the Universe, neutral kaons provide the only evidence yet seen for CP violation. The electric dipole moment of the neutron is also believed to depend slightly on CP violation, but experiments are not yet sensitive enough to measure this effect.

Neutral kaons and antikaons are strange particles, not simply because they contain a strange quark or antiquark, but because each is made up of a quantum superposition of two states. One of these can decay into a pair of pions with no violation of CP. The other, however, cannot, since the two pion system is in a different condition with respect to CP than the initial kaon. This state therefore has to find more complicated CP-conserving ways to decay, such as into a three pion system which is in the same CP-condition as the initial kaon. Consequently, this state lives longer and is known as K-long, K_L, the other being called K-short, K_S. The Cronin and Fitch experiment demonstrated that about one in 500 K_L decays produces just two pions, violating CP.

In the 1980s, CERN experiment NA31, and Fermilab's E731 and later E773 measured the relative decay rates of K_L and K_S into neutral and charged pion pairs. This measurement is extremely sensitive to CP, and since CP violation is a subtle effect, it is also extremely small and difficult to measure. However, an accurate measurement would show if the Cabibbo – Kobayashi – Maskawa mechanism provides for enough CP violation in the Standard Model to account for the observed matter antimatter imbalance, or if some other effect is at work. So the stakes are high.

NA31 and the two Fermilab experiments slowly converged on compatible results, but the results remained inconclusive. New experiments, NA48 at CERN (October 1995, page 16) and KTeV at Fermilab (November/December 1996, page 5), are now taking data which will repeat the measurements of their predecessors with ten times greater precision.

CPLEAR, in the meantime, has had other priorities. The experiment has concentrated more on CPT than CP, and has measured CPT and T symmetries individually as well as looking at CP violation.

The CPLEAR experiment

CPLEAR's neutral kaons and antikaons are produced when antiprotons from LEAR annihilate with protons in a hydrogen target. Four times out of a thousand, these annihilations produce a neutral kaon or antikaon along with a charged kaon and a pion. The charged kaon is detected and identifies what sort of neutral particle is produced. Negative kaons are produced along with neutral kaons, positive ones with neutral antikaons. It is this ability of CPLEAR to identify the initial particle which is the experiment's strong point.

For the measurement of CP violation, once the initial neutral particle has been identified, CPLEAR measures the time dependence of its decay rate to two charged pions. Neutral kaons and antikaons are made up of different amounts of K_L and K_S, so the time evolution of their decay curves is different and there is an interference effect between the two. This allows an accurate measurement to be made of the phenomenon since without CP violation there would be no interference.

CPLEAR's measurement is in good agreement with theory, but pleasing as this is, it does not in itself rule out significant CPT violation. This is because the measurement could mask a number of different CPT violating effects which cancel each other out. In order to make an unambiguous measurement, CPT must be measured directly, and this is where CPLEAR is unique. The electron and positron producing decays of neutral kaons are sensitive to T violation, and CPLEAR measures a T-violating parameter which is of the right magnitude to compensate the measured CP violation exactly, leaving CPT symmetry intact. Similarly, there are also CPT sensitive decays of neutral kaons and antikaons from which CPLEAR has measured a CPT violating parameter which is also consistent with no CPT violation.

So what?

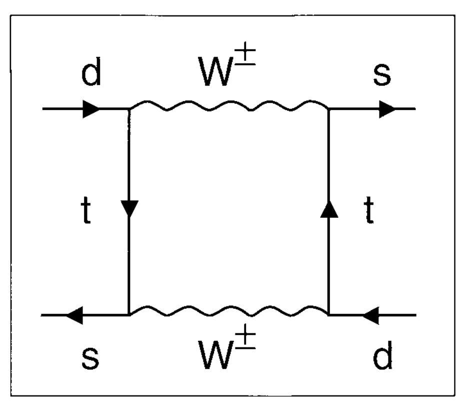
But what of the philosophical and down-to-earth implications mentioned earlier? The Standard Model can accommodate CP violation, but it doesn't explain it, nor does it say how much of it there should be. All the Standard Model says is that CP violation is possible as long as there are at least three families of matter particles. Measurements at CERN's Large Electron Positron collider, LEP, and the Stanford Linear Collider, SLC, in California indicate that there are precisely three families, just the number required, no more, no less. Furthermore, for the time being at least, theoreticians can sleep peacefully at night, since CPT does appear to be conserved. And as for the down-to-earth, without CP-violation, we simply wouldn't be here, and you don't get much more down-to-earth than that.

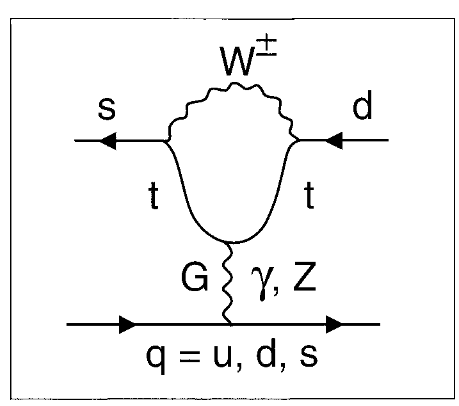
By James Gillies

DESY Theory Workshop

Discrete symmetries - the behaviour of particle interactions under distinct 'reflection' operations - could play an important role in a deeper understanding of the nature at both very small and large distances and provided the focus for the recent Theory Workshop at the DESY Laboratory in Hamburg.

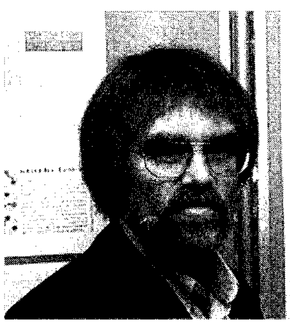
Special attention was paid to the violation of CP symmetry (see previous article). In the Standard Model of particle physics, CP violation is attributed to a relative phase in the three-dimensional (Cabibbo-Kobayashi-Maskawa -

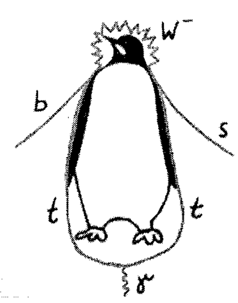


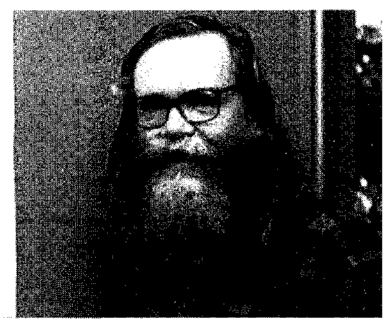


Quark mechanisms contributing to violation of CP symmetry: top, the 'box' diagram gives 'indirect' CP violation, while below, a so-called 'penguin' diagram gives 'direct' CP violation. Because the sixth ('top' - t) quark is so heavy, its contribution dominates.

Incongruous penguins. As birds, they are confined to the Southern Hemisphere. In physics, penguin mechanisms make for CP violation.
Andrzej Buras (left), Chairman of the recent DESY Theory Workshop and John Ellis of CERN, with a penguin of the physics kind.







CKM) matrix which parametrizes quark transitions under the weak nuclear force (mediated by heavy charged W bosons).

The original effect seen in the decays of long-lived neutral kaons into two pions in 1964 is attributed to 'indirect' CP violation through the mixing of the neutral kaon and its antiparticle and described by a box diagram (see top figure). This type of violation is usually characterized by a small parameter ε, measured to be roughly 2.3×10^{-3}.

However the Standard Model also allows 'direct' CP violation, characterized by a parameter ε', governed by the so-called "penguin" diagrams with internal exchanges of the sixth 'top' quark (see lower figure on page 24).

Because of the contributions of the top quark to the mechanisms, both these CP violation parameters are sensitive to that quark's mass. As summarized by Ahmed Ali (DESY) the most recent measurements of the CDF and D0 collaborations at Fermilab give a rather precise value of the top quark mass (175 $\pm$ 6 GeV) allowing improved predictions for CP violation.

The theoretical status of ε and of the ratio ε/ε' was summarized by Gerhard Buchalla (Fermilab). Refined gluon corrections and the more accurate top quark mass have both considerably improved the evaluation of CP violation parameters. While the indirect CP violation in the Standard Model is consistent with experimental data, strong cancellation effects between various penguin diagrams for the top quark mass of order 175 GeV and large hadronic uncertainties preclude a precise prediction for the ε ratio at present.

The experimental situation on this ratio is still uncertain, with minimal overlap between the results of the NA31 collaboration at CERN and E731 at Fermilab. Most theoretical estimates favour the lower Fermilab value, although due to hadronic uncertainties the CERN result cannot be excluded by the Standard Model. Within several years the experimental situation should be clarified through improved measurements at CERN and Fermilab and by the KLOE experiment at DAFNE in Frascati.

It is important to study other CP violating decays which are theoretically cleaner. As stressed by Buchalla, a "gold plated" decay in this respect is that of the long-lived kaon into a neutral pion, neutrino and antineutrino, proceeding almost exclusively through direct CP violation. The predicted branching ratio (3×10^{11}) and the presence of neutrinos and the neutral pion make the measurement of this decay formidable. Yet a newly approved experiment at Brookhaven should be able to measure it in the first years of the next millennium.

Similarly the very rare decay of the long-lived neutral kaon into a neutral pion and an electron-positron pair searched for at Fermilab (November 1996, page 5) should give important insight into direct CP violation.

While the CP violation has been observed so far only in kaon decays, where the effects are rather small, much larger effects are predicted for B mesons (containing the beauty quark). As stressed by Robert Fleischer (Karlsruhe) there are several decays where measurements should fix CP-violating phases without any hadronic uncertainties.

The large variety of CP-violating asymmetries in B-decays should allow for decisive tests of the Standard Model and possibly signal some new physics beyond it.

Thus CP violation in B-decays is the main goal of B-factories at SLAC (Stanford) and KEK (Japan) and of the dedicated HERA-B experiment at DESY in Hamburg which will all begin operation in a few years. Useful CP-violation studies in B-decays should also come from CESR at Cornell and from Fermilab's Tevatron. High precision measurements of CP-asymmetries in B-decays are expected from a dedicated experiment at CERN's LHC. A review was presented by Walter Schmidt-Parzefall (Hamburg).

According to the Standard Model, CP violation outside the K-meson and B-meson systems is expected to be essentially unobservable. On the other hand, as reviewed by Werner Bernreuther (Aachen), new sources of CP-violation, present in multi-Higgs models or models with supersymmetry could give rise to measurable effects.

Extensions of the Standard Model

predict new CP-violating interactions for quarks and for leptons. Attempts to trace such interactions include a forthcoming high statistics hyperon experiment at Fermilab, the "classic" low-energy searches for the neutron electric dipole moment and of certain atoms, and recent high-energy searches at CERN's LEP electron-positron collider of tau-pair production and in three-jet events from b quarks. Top quarks may also be used to probe CP violation once they are produced in large numbers at the Tevatron and the LHC.

Gian Giudice of CERN reviewed CP violation in supersymmetric theories, where present bounds on CP violation already give extremely important limits for the masses of supersymmetric particles. Searching for CP violation is thus complementary to high energy studies.

CPT invariance, the combination of CP symmetry with time reversal symmetry is the bedrock theorem of quantum field theory, enforcing, for instance ,equal masses for particles and antiparticles. As discussed by John Ellis of CERN, the most stringent tests of CPT come from the neutral kaon system in which the relative mass difference of the two particles is less than 9×10^{-19}. Ellis discussed various tests of CPT in CPLEAR experiment at CERN, possible tests using antihydrogen atoms and tests to be performed at DAFNE.

Graham Ross (Oxford) and Stewart Raby (Ohio) reviewed other aspects of discrete symmetries. Ross stressed the need for discrete symmetries in extensions of the Standard Model to keep everything under control. Discrete symmetries also play an important role in the attempts to understand quark and lepton masses.

Reviewing progress on theories of quark masses and mixings, Raby discussed SO(10) supersymmetric grand unification theories, which offer the simplest explanation for the observed Standard Model couplings. Some versions even fit the observed quark and lepton masses. These ideas can be tested in the future B factories, or at underground studies such as SuperKamiokande and Icarus via nucleon decays.

Pierre Sikivie of Florida reviewed the status of the 'strong CP problem' - why the strong interactions conserve P and CP symmetries although the Standard Model as a whole does not. The most interesting solution invokes a light spin zero particle, the axion. Constraints from high energy physics searches, stellar evolution and cosmology put the axion mass in the range 10^{-3} to 10^{-7} eV. The axion would then contribute to the dark matter of the universe and could be detected on Earth.

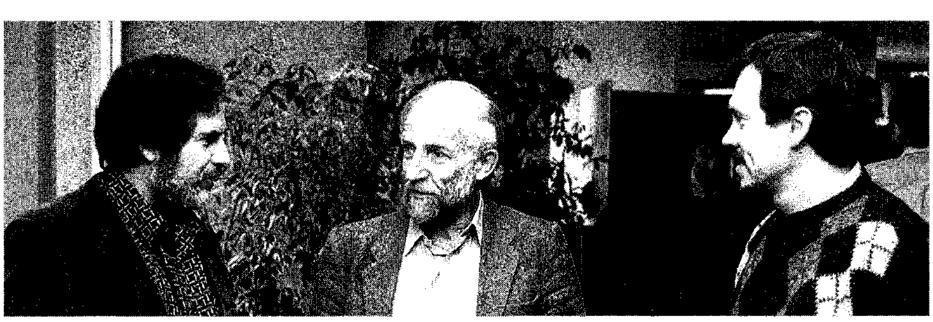
The baryon asymmetry in the Universe (matter-antimatter asymmetry), in which CP violation is believed to play an important role, was highlighted by Kimmo Kainulainen of CERN. However this huge asymmetry is not yet understood, and to answer this question needs a testable theory of how a Universe containing more baryons than antibaryons evolved from a baryosymmetric Big Bang. A candidate for such a testable theory is the minimal supersymmetric standard model but its ability to generate the required asymmetry remains to be proven.

The final talks turned to a somewhat different topic: neutrino masses and mixings. Jürgen Brunner from CERN reviewed the status of experiments searching for neutrino oscillations, where the current situation is confused. Brunner looked forward to clarification from new results which could come in the next few years, or even months.

Alexei Smirnov (Trieste) discussed possible patterns of neutrino masses and mixing, which may substantially differ from those in the quark sector. He also reviewed the possibility of CP-violation in neutrino oscillations - substantial in the case of large mixing. Future long-baseline experiments could search for such effects.

The DESY workshop certainly showed that discrete symmetries and related issues remain key questions of particle physics.

From Andrzej Buras (Munich Technical University)



Stewart Raby (Ohio, left), Graham Ross (Oxford, centre) and Alexei Smirnov (Trieste) discuss fermion masses at the DESY Theory Workshop.

Bookshelf

Particle Physics - One Hundred Years of Discoveries, V.V. Ezhela et al, American Institute of Physics Press, ISBN 1 56396 642 5

Several years before the official start of the 20th century, a series of milestone physics experiments pioneered the science which eventually became to be known as particle physics. A new book by several authors from the COMPAS group at the Institute for High Energy Physics, Protvino, near Moscow, and from the Particle Data Group effort at the Lawrence Berkeley Laboratory, reinforced by J.D. Jackson, has compiled a useful summary and bibliography of more than 500 key papers marking the development of particle physics from 1895 to the discovery of the top quark in 1995. Some 70 percent of the listed papers are post World War 2. The book is comprehensively indexed, including members of large collaborations and providing a useful benchmark. However actual entries confusingly use the first listed member of the collaboration, even if a Nobel Prize was subsequently awarded to another member of the team.

Infinite Potential - The Life and Times of David Bohm, by F. David Peat, Addison Wesley, ISBN 0 201 40635 7, $25

Throughout his life, David Bohm felt himself to be different, and this was reflected in his lifestyle and in his physics. His life was one of unfulfilled searching. If one compares mainstream physics to the church, with a solid hierarchy of cardinals, archbishops and bishops, Bohm was an ascetic hermit who would occasionally come in from the wilderness with a compelling message, only to disappear again. Bohmian quantum mechanics is not part of mainstream physics, but for those who do cross over, like John Bell, the commitment can be rewarding. In the post-war 'Un-American Activities' purge, Bohm lost a prestigious job at Princeton and temporarily his US citizenship, and his nomadic career took him to Brazil, Israel and Bristol before he finally settled in London's Birkbeck College. A sensitively-written book about a gifted, unusual and sometimes provocative figure. The interaction between Bohm and Oppenheimer is especially interesting, while Bohm's later life was bizarre.

GF

QCD and Collider Physics, by R.K. Ellis, J. Stirling and B. Webber, published by Cambridge University Press, ISBN 0 521 58189 3, price £35/$49.95 (hbk)

Analysing experimental results in the light of QCD is a major responsibility in any modern particle physics experiment. For experimentalists, QCD is notoriously difficult to handle, but this authoritative book by well-known and respected phenomenologists traces a clear path through the QCD jungle and deserves to become a standard reference.

EPAC 96 - Proceedings of the 5th European Particle Accelerator Conference, held in Sitges, near Barcelona, 10-14 June.

These proceedings have been rapidly published by the UK Institute of Physics Publishing in an initial CD-ROM form (the book version took a bit longer). The impressive CD includes an Acrobat reader to enable the contents to be searched using and/or criteria. To accomplish all this took a lot of effort (September 1995, page 8), but this is clearly the way to go.

Books received

Feynman Lectures on Computation, by Richard P. Feynman, edited by Anthony J.G. Hey and Robin W. Allen, Addison Wesley, ISBN 0 201 48991 0.

An imaginatively and carefully edited item of Feynman memorabilia, based on courses given at Caltech from 1983-86.

The Picture Book of Quantum Mechanics, by Siegmund Brandt and Hans D. Dahmen, published by Springer, ISBN 0 387 94380 3 price DM78 (hbk)

A fresh look at quantum mechanics, including some 200 computer-generated illustrations showing the time evolution and parameter dependence of many different wave equations.

People and things

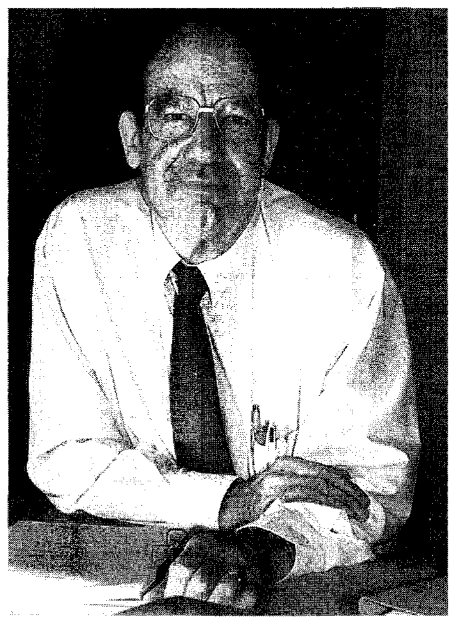
On people

A prestigious Max Planck research prize goes to distinguished Russian experimentalist Michael Danilov for research at the DESY Laboratory, Hamburg. Deputy director at Moscow's Institute of Theoretical and Experimental Physics (ITEP), Michael Danilov has been a major participant in DESY research since 1978, having been a key member of the ARGUS experiment, and is one of the initiators of the HERA-B experiment which is to be commissioned in 1998. Germany's Alexander von Humboldt foundation and Max-Planck Association award the Max Planck research prize annually to six foreign and six German researchers to stimulate a flexible environment for joint research by German and foreign partners.

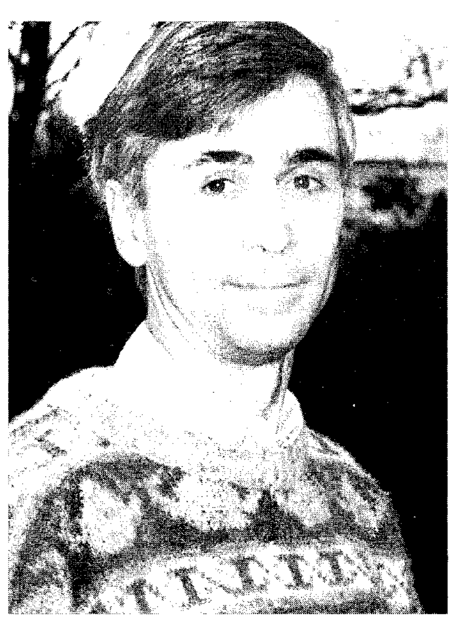
Bastiaan ('Bas') de Raad retires

After a 42-year career spanning almost all CERN's history, Bastiaan ('Bas') de Raad retired at the end of 1996. His methodical approach and meticulous care have ensured that CERN's accelerators have overcome challenges foreseen and unforeseen. Arriving in 1954, he joined the proton synchrotron magnet group, faced with the challenge of building a strong focusing machine, where he contributed first to magnet measurements and then to beam transfer magnets. In 1964 he joined the future ISR team, where he went on to become responsible for beam transfer, injection and dumping for the world's first proton collider. Following the commissioning of the ISR in 1971, he moved to the '300 GeV project', later the Super Proton

Bastiaan ('Bas') de Raad - 42 years at CERN



Synchrotron, where he was one of John Adams' group leaders, again looking after beam injection and ejection. Then came a series of key SPS roles, chairman of the running-in committee, leader of the combined accelerator groups, and finally Division Leader from 1981. During this period, the SPS saw its finest hour as a Nobel Prize-winning proton-antiproton collider, and went on to handle beams of heavy ions. With the SPS also faced with the challenge of having to inject electrons and positrons for LEP, de Raad conceived an ingenious scheme to safeguard the machine, designed to handle protons, from harmful electron synchrotron radiation, with carefully-placed diaphragms and screens, supplemented by lead shielding. With this shining armour, the SPS sailed gracefully into the LEP era. From 1991-96 de Raad culminated his CERN career as Leader of the Technical Inspection and Safety Commission.



Michael Danilov - Max Planck research prize

Lohrmann retirement

A special symposium at the German DESY Laboratory, Hamburg, on 25 October, organized jointly with Hamburg University, marked the formal retirement of Erich Lohrmann, who for over 30 years has pushed the study of elementary particles in Hamburg, decisively shaping the contours of the discipline. As well as his own contributions to particle physics, his support of younger scientists has been much appreciated. After graduating in 1956, he worked on cosmic rays and elementary particles in Stuttgart, Bern, Frankfurt and Chicago. In 1961 he came to DESY, where he stimulated German-French collaboration in one of the first bubble chamber experiments at the new laboratory. He soon advanced to Leading Researcher and from 1968-74 and from 1979-81 was DESY Research Director. At CERN, he was a member

Erich Lohrmann (right) at his retirement symposium at DESY with his former Stuttgart research supervisor Erwin Schopper.

of the Scientific Policy Committee from 1981-86 and Research Director from 1976-78. Most recently at DESY he has been involved in the Zeus experiment at HERA. In 1976 he became Professor at Hamburg and went on to become dean of physics. He has also chaired the high energy physics advisory committee of the Federal Minister of Research.

A.A. Logunov's 70th birthday

On 30 December Anatoly Alexeyevitch Logunov, Director of the Institute of High Energy Physics at Serpukhov, near Moscow, celebrated his 70th birthday. During his more than 40-year scientific career he has made fundamental contributions to the early development of the renormalization group methods, to the proof and use of the dispersion relations and to rigorous high-energy asymptotic theorems. He and his collaborators adapted the power of the axiomatic approach to the study of analytical structure and high-energy behaviour of multiparticle amplitudes with the use of what were later called "inclusive processes". His name is also related to pioneering papers on finite energy sum rules and the "quasipotential" approach in quantum field theory. In recent years he has devoted much attention to a consistent formulation of the theory of gravitation.

In addition to his scientific achievements, he is also one of the key figures in the organization of high energy physics research in the USSR and Russia. In 1963 he was nominated Director of the newly-created Institute for High Energy Physics in Protvino, near Serpukhov (Moscow Region). Under his leadership the 76 GeV accelerator, the biggest in the world at the time, was constructed and commissioned in 1967. He has also initiated and strongly promoted a wide and close collaboration with CERN, France and the USA. In 1974- 91 he was Vice-President of the Academy of Sciences of the USSR, and in 1977-92 Rector of Moscow State University.

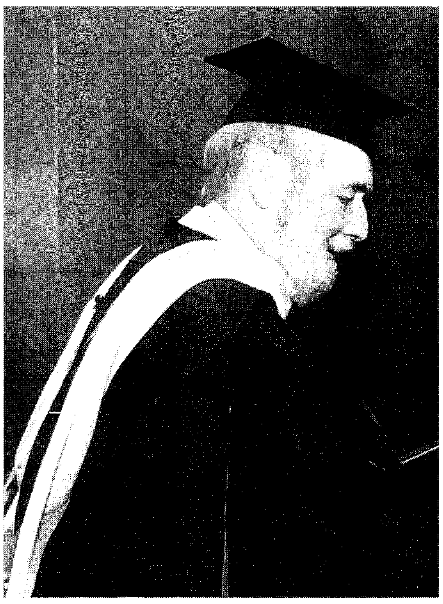
Anatoly Alexeyevitch Logunov - 70

IUPAP elections

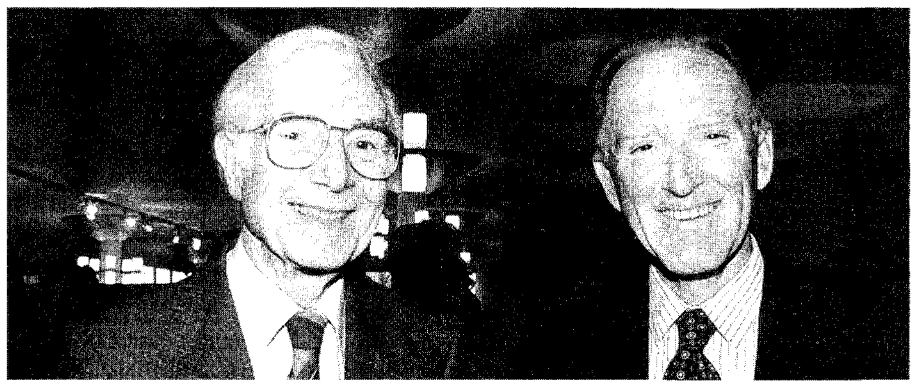
At its recent General Assembly in Uppsala, Sweden, the International Union of Pure and Applied Physics (IUPAP) elected Jan S. Nilsson of Stockholm's Wallenberg Foundation as President of the Executive Council, succeeding Yoshio Yamaguchi of Tokai. Secretary General is René Turlay of Saclay, and President Designate is Burton Richter of SLAC, Stanford. The new chairman of IUPAP's C11 Commission on Particles and Fields is Barry Barish of Caltech.

Mikhail Vasilievich Terentyev (1935-1996)

Distinguished Russian theorist Mikhail Vasilievich Terentyev died in Moscow on 26 September. After graduating from Moscow's Institute of Physics and Engineering in 1959, he joined the Theoretical Department of the Institute for Theoretical and Experimental Physics, where he worked for the rest of his life. One of the most talented students of V.B.Berestetskii, Misha Terentyev made many important contributions to particle theory. In 1963 he found a non-renormalization theorem for a



Ednor M. Rowe 1928-96



The traditional John Adams Memorial Lecture at CERN in November this time marked 50 years of synchrotrons (September 1996, page 10). John Lawson (left), formerly of the UK Rutherford Appleton Laboratory and who was close collaborator of John Adams at the UK Harwell Laboratory, spoke on early synchrotron history in Europe, while Giorgio Brianti (right), formerly of CERN, covered the CERN machines.
(Photo CERN HI 10.11.96)

weak vector isovector current. (A year later an analogous theorem for a changing strangeness vector current was discovered by Ademollo and Gatto.) In 1965 (in collaboration with V.S. Vanyashin) he was the first to find that vector bosons give a "wrong sign" contribution to the renormalization of the electromagnetic charge, a phenomenon later understood as "asymptotic freedom" of non-abelian fields. For many years he was the Editor of "Yadernaya Fisika". In the last year of his life, while suffering from leukemia, he started to teach at Moscow Institute of Physics and Engineering and started to prepare a major course of lectures on elementary particle theory. M.V.Terentyev was a very generous and kindhearted man - the conscience of ITEP's Theoretical Department. He lives in the hearts of all those who worked with him, and who respected and admired him.

Ednor M. Rowe 1928-96

Ednor M. Rowe, founder of Wisconsin's Synchrotron Radiation Centre and a leading force behind its success, died last year. In the 1960s at the Mid-Western Universities Research Association (MURA) in Madison he became head of the r.f. group, working on new accelerator ideas. With the dissolution of MURA in 1967 he joined the staff of Madison-Wisconsin, where he pushed for the establishment of the Synchrotron Radiation Centre, serving as its Director from 1970-83. With Fred Mills, he designed and built the 240 MeV Tantalus electron storage ring, subsequently converted into a dedicated synchrotron radiation source and the forerunner of Wisconsin's big Aladdin ring.

Virendra Singh, Director of the Tata Institute for Fundamental Research, Mumbai (Bombay) inaugurated the Golden Jubilee 'Sujayata' theoretical physics symposium with a talk on the founder of the Tata Institute, Homi Bhaba (inset), and the development of theoretical physics at the Tata Institute.

The travelling exhibition 'Hadrons for Health' managed by Werner Kienzle of CERN and Alessandro Pascolini of Padua was recently on show at the Czech Academy in Prague. Left to right - Werner Kienzle, Maurice Jacob, who opened the exhibition on behalf of CERN, and Jiri Niederle, Vice Chairman of CERN Council and Director of international affairs for the Czech Academy.

Cormac O Ceallaigh 1912-96

Cormac O Ceallaigh (pronounced O'Kelly), who died on 10 October, made major contributions to cosmic ray physics. After working under Rutherford at the Cavendish Laboratory, Cambridge, in the 1930s and under Powell at Bristol from 1949-53, in 1953 he moved to the Dublin Institute for Advanced Studies, where his experiments continued through to the era of the Space Shuttle.

Peter Fowler 1923-96

Peter Fowler, the grandson of Ernest Rutherford, was, like O Ceallaigh, a member of Cecil Powell's cosmic ray group at Bristol. An ingenious experimenter, he continued his studies using airborne detectors in balloons, aircraft and satellites, where his results on heavy nuclei provided valuable input for our understanding of element formation in supernovae.

J.M. Valentine 1925-96

Former Rutherford Appleton Laboratory Secretary J.M. ('Jim') Valentine died on 31 October. After a PhD in nuclear physics at Glasgow and an initial career in medical physics, he joined the Rutherford Laboratory in 1962 and served as Laboratory Secretary from 1963 until his retirement in 1990, overseeing the 1979 merger with the Appleton Laboratory.

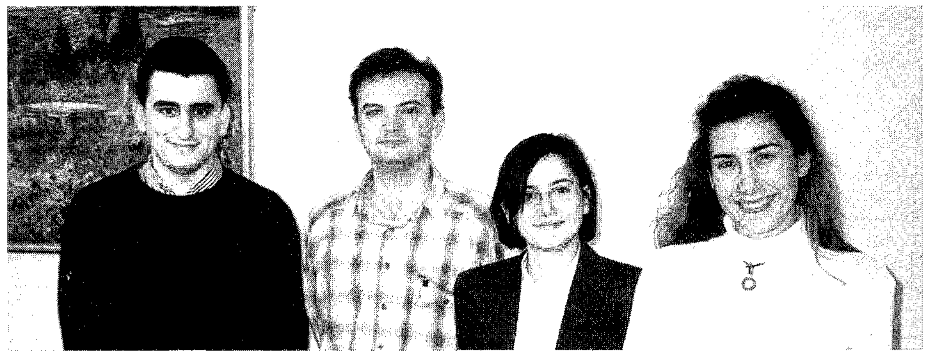
The linear collider route

As well as CERN's LHC proton-proton collider, the other route towards the high energy frontier is via a linear electron-positron collider, the physics coverage of these two routes being seen as complementary.

Over the past year, a series of meetings organized by the European Committee for Future Accelerators (ECFA) and the German DESY Laboratory, Hamburg, have examined the physics possibilities and detector requirements for this research at collision energies of 500 GeV and more. After meetings at Frascati, DESY, CERN, London, and Munich, a final meeting was held at DESY in November. The outcome will be a report submitted to the German Science Council next spring. Physics aims can broadly be classified under investigating the top quark, the W boson, the Standard Model and the higgs mechanism, and supersymmetry.

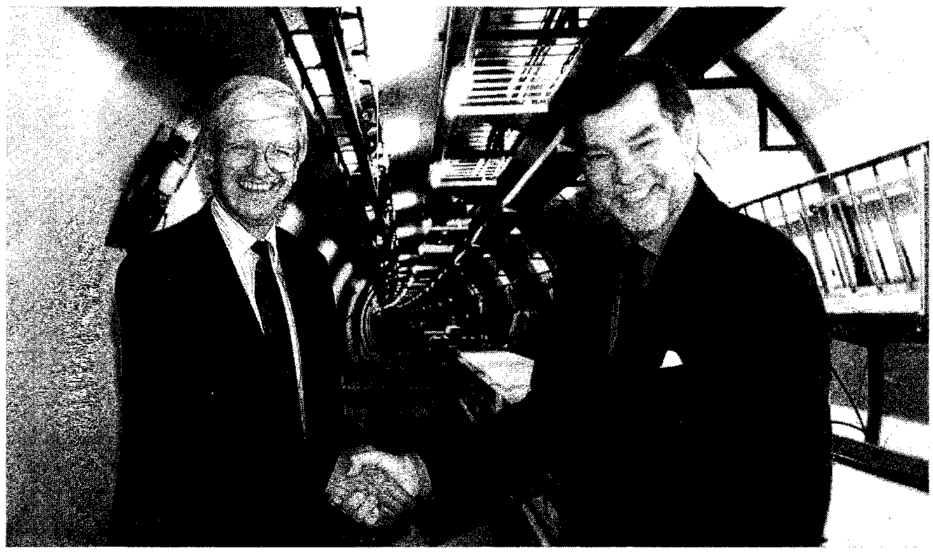
While this study reflects the effort going on in Europe, and in particular at DESY, where in particular linear collider machine research and development explores the superconducting TESLA and the more classic S-band radiofrequency, work is continuing in specialist

Under a recent agreement between CERN and the Spanish Centre for Industrial and Technological Development (CDTI), each year five young engineering graduates will come to CERN with Spanish support for two years of training in accelerator-based high technology. The first to arrive were (left to right) Guilermo Calviño Palacios, Julio Lucas Torrabla, Isabel Bejar Alonso and Montserrat Pol Fraga. (Photo Maurice Jacob)



Opening the seventh 'Italy at CERN' trade show on19 November, Italian Minister for Universities and Scientific and Technological Research Luigi Berlinguer was presented with a copy of 'Nel Mistero dell Universo', the Italian edition (De Agostini, Novara) of 'Search for Infinity', the book on CERN science by Gordon Fraser, Egil Lillestøl and Inge Sellevåg. (Photo CERN HI 25.11.96)

Visiting CERN in November was Swedish Minister for Trade Bjørn von Sydow (right), seen here with CERN Director General Chris Llewellyn Smith. (Photo CERN HI 7.11.96)



laboratories across the world, with other scenarios in view.

Meetings

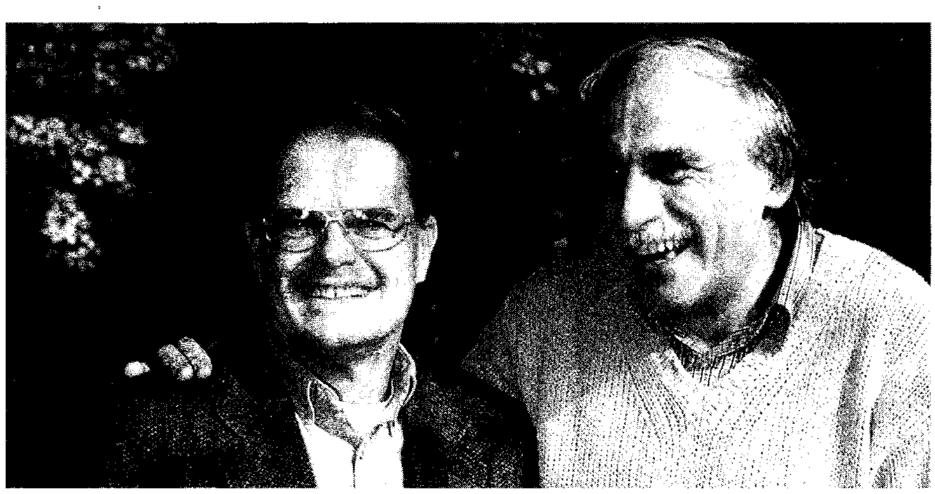
The next High Energy Physics International Euroconference on Quantum Chromodynamics (QCD97), marking the 25th anniversary of QCD, will be held from 3-9 July in Montpellier (France). Deadline for registration, abstracts and papers is 9 May. Contact : QCD secretariat or S. Narison, Laboratoire de Physique Mathématique et Théorique, UM2, Place Eugène Bataillon, 34095 Montpellier Cedex 05 (France). Phone: (33) 04 67 14 35 68 Fax: (33) 04 67 54 48 50, e-mail: qcd@lpm.univ-montp2.fr

The International Conference on Hypernuclear and Strange Particle Physics - HYP97 - will take place from 13-18 October at Brookhaven National Laboratory, Upton NY 11973, USA. Contact R. E. Chrien, Bldg 510A, BNL, Upton NY 11973, Telephone: 516-344-3903, email Chrien@bnl.gov fax: 516-344-5568

The International Symposium on "Strangeness in Quark Matter" will be held from 14-18 April in Santorini, Greece. Contact SQM97@atlas.uoa.gr or Apostolos.Panagiotou@cern.ch

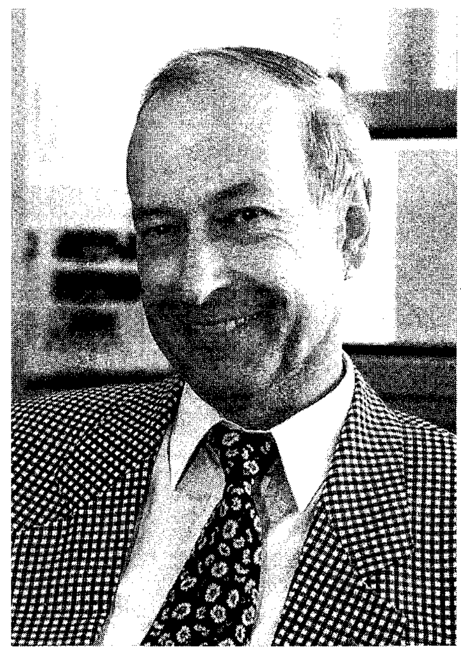
The 6th Workshop on Heavy Charged Particles in Biology and Medicine will be held at Baveno, Lago Maggiore, Italy, from 10-12 September, the week preceding the International Conference on Medical Physics in Nice. Information from Roberto Cirio, INFN TO, Via Giuria 1, I-10125 Torino, fax +39 11 6699579, Gerhard Kraft, Biophysics GSI, Planck Str. 1, D-64291 Darmstadt, fax +49 6159 712106, or Enzo Sacco, IEO sez. TERA MI, via Ripamonti 435, 20141 Milano, fax +39 2 57489208

The Proceedings of the 1996 Zuoz Summer School on Physics with



Heavy ion transition. Old and new spokesmen for the NA49 experiment at CERN - Reinhard Stock (right) of Frankfurt hands over to Peter Seyboth of Munich's Max Planck Institute.

New Division Leaders at CERN: left to right - Jürgen May (Information Technology), Romeo Perin (Supplies, Procurement and Logistics) and Helmut Schönbacher (Technical Inspection and Safety Commission)



Neutrinos is available from Christine Kunz, Paul Scherrer Institute, Würenlingen and Villigen, 5232 Villigen PSI, Switzerland. Tel +41 56 310 42 23, fax: +41 56 310 32 94, e-mail christine.kunz@psi.ch

Beyond the LHC

Very Large Hadron Collider Physics and Detector Workshop Physics At The High Energy Frontier Beyond the LHC is the title of a workshop sponsored by Fermilab and the US Department of Energy to be held March 13-15 at Fermilab. It will concentrate on the physics and detector issues associated with a hadron collider with a collision energy of the order of 100 to 200 TeV.

Further information from Diane Sellinger, Physics Section, Fermi National Accelerator Laboratory, MS #122, P.O. Box 500, Batavia, Illinois 60510, Phone: 630 840-3201, E-mail: sellinger@fnal.gov .

Last summer, CERN translator François Siohan (who handles the lion's share of the translation for the French edition of the CERN Courier) bravely set out to break the world cycling record for vertical height in 24 hours. Using the 11.2 kilometre stretch between Gex at the foot of the Jura mountains near CERN and the Faucille (sickle) pass, the indomitable François, 55, relentlessly scaled the 711 metre ascent 21 times, making a total climb of 14,931 metres. The previous record was 13,552 metres.

External correspondents

Argonne National Laboratory, (USA)
D. Ayres

Brookhaven, National Laboratory, (USA)
P. Yamin

CEBAF Laboratory, (USA)
S. Corneliussen

Cornell University, (USA)
D. G. Cassel

DESY Laboratory, (Germany)
P. Waloschek

Fermi National Accelerator Laboratory, (USA)
Judy Jackson

GSI Darmstadt, (Germany)
G. Siegert

INFN, (Italy)
A. Pascolini

IHEP, Beijing, (China)
Qi Nading

JINR Dubna, (Russia)
B. Starchenko

KEK National Laboratory, (Japan)
S. Iwata

Lawrence Berkeley Laboratory, (USA)
B. Feinberg

Los Alamos National Laboratory, (USA)
C. Hoffmann

NIKHEF Laboratory, (Netherlands)
Margriet van der Heijden

Novosibirsk Institute, (Russia)
S. Eidelman

Orsay Laboratory, (France)
Anne-Marie Lutz

PSI Laboratory, (Switzerland)
P.-R. Kettle

Rutherford Appleton Laboratory, (UK)
Jacky Hutchinson

Saclay Laboratory, (France)
Elisabeth Locci

IHEP, Serpukhov, (Russia)
Yu. Ryabov

Stanford Linear Accelerator Center, (USA)
M. Riordan

TRIUMF Laboratory, (Canada)
M. K. Craddock

CERN Council

The December meeting of CERN's governing body, Council (see page 1) was the last to be presided over by Hubert Curien of France. Luciano Maiani of Italy now takes over. At the December meeting, Fernando Barriero of Spain was appointed to the Scientific Policy Committee. Alberto Scaramelli is appointed leader of CERN's Technical Support Division from 1 July, succeeding Fritz Ferger, and Alvaro de Rùjula is appointed leader of CERN's Theory Division from 1 July, succeeding Gabriele Veneziano.

DOE Office of High Energy and Nuclear Physics

In the US Department of Energy (DOE), S. Peter Rosen has been appointed Associate Director for High Energy and Nuclear Physics (HENP), taking over from Director of the High Energy Office John O'Fallon who has been serving as Acting Associate Director for High Energy and Nuclear Physics following the retirement of Wilmot Hess.

Claudio Villi 1922-1996

Claudio Villi, theoretical physicist and former President of the Italian Istituto Nazionale di Fisica Nucleare (INFN), died on 18 December. Born in Trieste, he took part in the Italian liberation with the British army, subsequently graduating in physics at Trieste and starting nuclear physics research with the Padua theoretical group. His main contributions were in the area of nuclear structure and reactions,

Claudio Villi 1922-1996

including a model for the internal structure of the nucleon, which was probed in the historic Stanford experiments by Robert Hofstadter. In 1960 Villi became professor of theoretical physics at Parma and in 1962 moved to Padua to teach nuclear physics and then mathematical methods till his retirement.

He pushed the development of nuclear physics in Italy, promoting in particular the upgrade of the Legnaro National Laboratory and the creation of the National Southern Laboratory at Catania. He served as INFN President from 1970 - 75 and succeeded in strengthening the structure of INFN and its role as a State institution, in creating a network of relations with Italian universities and other research bodies, and in promoting international cooperation.

In 1976 he was elected Senator of the Italian Republic, paying particular attention to science, energy and environmental problems. A man of *broad scientific, cultural and social interests, he gained prestigious awards for his scientific activity, his devotion to the development of science and for the promotion of international cooperation.*

UK Institute of Physics Awards

The 1997 list of awards by the UK Institute of Physics includes four people well-known at CERN, either directly or through their work.

Alexander Donnachie of Manchester receives the prestigious Glazebrook Prize. As well making many contributions to phenomenology, he has also been Head of the High Energy Particle Physics Division at the UK's Daresbury Laboratory, a member of CERN's Research Board and Chairman of the SPS Experiments Committee. He has recently served on a review committee for Dutch physics.

Peter Higgs of Edinburgh receives the prestigious Paul Dirac Prize for his contributions to gauge invariant field theories and to the spontaneous symmetry breaking mechanism which customarily bears his name.

Roger Forty of CERN receives the Charles Vernon Boys Prize, reserved for young researchers, for his work on B-particle physics with the Aleph experiment at CERN's LEP electron-positron collider.

Timothy Berners-Lee of MIT receives the Duddell Prize for his invention of the World Wide Web at CERN in 1989.

Meeting

The 5th Topical Seminar on "The Irresistible Rise of the Standard Model" will take place in San Miniato al Todesco, Italy, from 21-25 April at the Centro Studi "I Cappuccini". The Seminar is organized by F.-L. Navarria/Bologna and P.G. Pelfer/Firenze, and is sponsored by INFN, Universita di Bologna, Universita di Firenze, Regione Toscana. Attendance, by invitation only, will be limited to approximately one hundred. Information: F.-L. Navarria, Dipartimento di Fisica, V.le Berti-Pichat 6/2, I-40127 Bologna, tel +39 51 6305082/6305101, fax +39 51 247244, e-mail kaos@bo.infn.it http://www.bo.infn.it/conferences/sminiato-new/sminiato97.html

RESEARCH GROUP LEADER

Advanced Photon Source

Argonne National Laboratory, located 20 miles southwest of Chicago, is one of the premier scientific research and development organizations in the United States. An opportunity to lead the Laboratory's Accelerator Physics Group now exists for a physicist who has achieved a position of stature in the field of accelerator physics, and is specifically acknowledged for research and leadership in the area of synchrotron light sources.

We would look to the selected candidate to develop and maintain an excellent accelerator research program, by expanding the capabilities of the Advanced Photon Source accelerator systems and developing innovative accelerator physics concepts into new research opportunities. Responsibilities include providing technical leadership and management supervision to the Group, organizing seminars and a visiting scientist program and undertaking occasional teaching responsibilities sat the University of Chicago.

Qualified candidates will possess a level of knowledge typically achieved with 10+ years' experience in accelerator physics research as well as an established reputation in the accelerator community at large. Experience in supervising the research of Ph.D. candidates and postdoctoral researchers, and directing a research group is necessary. Ph.D. or equivalent credentials are a requisite.

Argonne offer a stimulating professional environment, competitive salary and excellent benefits package. For consideration, please send your resume and the names and addresses of three references to: Argonne National Laboratory, Attn: Walter D. McFall, Box APS-117811-60, Employment and Placement, 9700 South Cass Avenue, Argonne, IL 60439. Telecommunications Device for the Deaf 630/252-7722. Resumes are electronically scanned and processed. A letter quality resume with a standard typeface is required (no underlines or bold, please). An Equal Opportunity/Affirmative Action Employer.

For additional information, please refer to Argonne's Home Page on the Internet — http://www.anl.gov/welcome.html.

ARGONNE NATIONAL LABORATORY • UNIVERSITY OF CHICAGO •

UNIVERSITY OF FLORIDA
EXPERIMENTAL HIGH ENERGY PHYSICS
ASSISTANT PROFESSOR

The University of Florida invites applications for a tenure track Assistant Professor position in experimental high energy physics to begin August 1997. Requirements include a Ph.D., demonstrated accomplishments in this field of research and good teaching ability.

The new faculty member would become part of a strong and rapidly expanding research group that presently includes five high energy experiment faculty and seven high energy theory faculty. The experimental group will continue to expand in the future in the area of hadron collider physics. Currently the Florida group is leading in the design and construction of the Endcap Muon System of the CMS experiment at CERN. We also participate in the CLEO experiment at Cornell and the CDF and MINOS experiments at Fermilab. One of the major muon detector development/testing sites for CMS is expected to be located in Florida. The new faculty member is expected to play a leading role in hadron collider experiments (CMS and CDF). Our work in these activities is enhanced by a powerful simulation and data analysis computer system, and the construction of a new building for the physics department which will have large and well equipped laboratory space for hardware development and will be completed late 1997.

Applicants should send curriculum vitae, bibliography and a description of research and teaching interests to HEE Search Chair, Department of Physics, P.O. Box 118440, Gainesville, FL 32611. Please arrange to have your reference letters sent or provide the names of at least three references for the Committee to contact. Applicants with questions may contact the Search Chair, Professor Guenakh Mitselmakher, by mail or by email at Mitselmakher@phys.ufl.edu or by telephone at 352/392-5703. The office fax number is 352/392-8863. The deadline for receipt of applications is February 28, 1997.

The University of Florida is an equal employment opportunity/affirmative action employer. Anyone requiring special accommodations to complete applications should contact the Search Committee Chair.

Research Associate Position
University of Virginia
Experimental High Energy Physics

The University of Virginia Experimental High Energy Physics group is seeking qualified applicants for a Research Associate position to work on the physics of CP violation. On the short term, this work will focus on the KTEV experiment at Fermi National Accelerator Laboratory, and on a longer time scale, on the LHC-B beauty physics experiment at CERN. This position is now open. The successful candidate is expected to play an important role in the KTEV experiment in the operation of an e+e- trigger based on a transition radiation detector and in the development of lepton detectors and triggers for the LHC-B experiment. Applications including curriculum vitae, a list of publications, and three letters of reference should be sent to:

Prof. B. Cox
Physics Department, McCormick Rd.
University of Virginia
Charlottesville, VA 22901

Information concerning this position may be obtained through **e-mail** at:

Cox@UVAHEP.phys.virginia.edu

The University of Virginia is an equal opportunity employer.